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ABSTRACT

In this set of six booklets on collecting data, intermediate grade students learn how to collect good data, round off and record data, do an experiment, make an opinion survey, and choose a sample. The major emphasis in all Unified Sciences and Mathematics for Elementary Schools (USMES) units is on open-ended, long-range investigations of real problems. In most instances students learn through observing results of their own and their classmates' experiments. However, students may recognize the need for certain facts and/or skills during their investigations. Although some children prefer to work things out for themselves, others may ask for help. USMES "How To Sets" are designed to provide such assistance. Each booklet in a set contains several examples or stories about students using the skill or process being taught, each example emphasizing a different aspect of the skill or a potential pitfall. The first page tells why or when students may need the skill covered in the booklet and includes a table of contents. There is no sequence to the sets (or booklets within sets) and they should not be used out of the context of childrens' open investigation of a practical problem. (Author/JN)

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ED220327

USMES INTERMEDIATE
UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS

HOW TO SET

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COLLECTING DATA

SE 039 089

WHAT IS USMES?

USMES challenges students to solve real problems within their school and community. Students tackle problems like a busy or unsafe intersection near their school, classroom furniture that doesn't fit them, or playgrounds that are crowded or uninteresting. These problems have immediate and practical impact on students. They have no established, correct solutions--students take or recommend action based upon whatever data they collect and analyze. Furthermore, the students themselves, not the teacher, direct the problem-solving process.

Solving real problems is interdisciplinary: skills, processes, and concepts from science, mathematics, social science, and language arts all play a part. For example, students conduct opinion surveys, build measuring devices, write letters, and make and use graphs. They also make decisions, work productively in small groups, and develop and clarify values.

The USMES curriculum is organized into twenty-six problems, or units, that have been developed in the classroom by teachers and students in a wide variety of schools. Most units can be used in grades K-8 although the level at which students approach a problem and develop a solution will vary according to age, ability, and interest.

RESOURCES FOR AN USMES PROGRAM

In addition to the USMES "How To" Series, there are--

The USMES Guide: This book describes the USMES project, real problem solving, classroom strategies, the Design Lab, the units, and the support materials as well as ways that USMES helps students learn basic skills. A section in the guide correlates the twenty-six USMES units with topics in Science, Mathematics, Social Science, Language Arts, Career Education, and Consumer Education.

Teacher Resource Books (one per unit): Each of these guides to using USMES units describes a broad problem, explains how students might narrow that problem to meet their particular needs, recommends classroom strategies, and presents logs from teachers whose classes have worked on the unit.

Design Lab Manual: This guide helps teachers and administrators set up, run, and use a Design Lab--a place with tools and materials where students can build things they need for their work on USMES units. A Design Lab may be a corner of a classroom, a portable cart, or a separate room.

Background Papers: These papers provide teachers with information and hints that do not appear in the student materials.

The "How To" Series is a resource developed by the USMES project. Earle L. Lomon, Project Director, Betty M. Beck, Associate Director for Development, Thomas L. Brown, Associate Director for Utilization Studies, Quinton E. Baker, Associate Director for Administration.

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Complete USMES Library ISBN: 0-89292-033-5
Intermediate "How To" Series ISBN: 0-89292-030-0

THE USMES INTERMEDIATE *HOW TO* SERIES

USMES and Skills

USMES students often see a need to learn new skills to help them get a problem-solving job done. Students seeking to improve a street crossing may want to learn how to use a stopwatch or how to make a trundle wheel. Students comparing different brands of paper towels may want to learn how to design an experiment and how to make a bar graph. The list can go on and on, but the pattern is clear; solving a real problem requires skills.

Purpose of 'How To' Series

Materials that help students learn skills like designing an opinion survey and choosing the appropriate measuring tool are not readily available for intermediate grade students. The USMES Intermediate "How To" Series fills this gap. Its magazine-style format helps students acquire the skills and knowledge they need to do things like redesign their classroom, find the best buy in potato chips, or run a school store.

How to Use the 'How To' Series

Wait for a need. When a student asks for help, refer him or her to the appropriate booklet. Having a student read a booklet before there is a need to do so will not only result in less effective learning but will defeat the USMES purpose of allowing students to decide what needs to be done.

When necessary, use the "How To" Series as a teaching aid. Most of the time students will be able to go through a booklet by themselves and learn the skills they need to learn. However, some material in some sets is difficult and somewhat abstract. When the booklet by itself is not doing the job, feel free to step in and help the student go through it.

Knowing how the contents of the booklets are organized may help in using the series effectively.

- The first page tells why or when a student may need the skill covered in the booklet, and includes a table of contents.
- Each booklet contains several examples or stories about students using the skill or process being taught. Each example emphasizes a different aspect of the skill or a potential pitfall.
- When information in other booklets may help the student, the titles of the booklets are included in the text.
- The last pages of each booklet contain a summary of the points covered in the booklet.

OTHER USMES *HOW TO* SERIES

Beginning "How To" Series: This cartoon-style series covers in less detail much of the same material as the Intermediate Series. Its cartoon-style format helps younger children and those with reading difficulties acquire the skills needed to work on a real problem.

Design Lab "How To" Series: These illustrated cards help children learn how to use tools safely and effectively.

"How To" Cards: This series is printed on colored card stock rather than paper. They contain fewer words than the Intermediate "How To" Series and utilize the American system of units (ft./lb./sec.) rather than the metric system. The Collecting Data set, however, is not available in the "How To" Cards.

INTERMEDIATE *HOW TO* SERIES

COLLECTING DATA

Collect Good Data
Round Off Data
Record Data
Do an Experiment
Make an Opinion Survey
Choose a Sample

GRAPHING

Choose Which Graph to Make
Make a Bar Graph
Make a Histogram
Make a Line Graph
Make a Conversion Graph
Use Graphs to Compare Two Sets of Data

MEASURING

Use a Stopwatch
Choose the Right Tool to Measure Distance
Use a Trundle Wheel
Make a Scale Drawing
Find the Speed of Things

SIMPLIFYING DATA

Tell What Your Data Show
Find the Median
Find the Mean
Find the Mode
Find Different Kinds of Ranges
Use Key Numbers to Compare Two Sets of Data

Conceived and Written by:
Sally Agro, Betty M. Beck, Ray L. Brady Jr., Jean Keskulla, Phyllis Klein

Production:
Paula Lakeberg, John Saalfield

edc

"HOW TO"

COLLECT GOOD DATA

ARE YOU COLLECTING DATA OR MEASURING TO FIND OUT--

How many? How heavy? How strong? How much time?

How long? How far? How hot?

Sometimes things go wrong when you collect data. If you want to use your data to decide something, you want your measurements to be right.

That's why you should--

1. DECIDE WHAT YOU WANT TO MEASURE.
2. MAKE SOME TEST MEASUREMENTS.
3. PLAN HOW YOU WILL MAKE YOUR MEASUREMENTS.
4. MAKE YOUR MEASUREMENTS CAREFULLY.
5. REPEAT YOUR MEASUREMENTS. LOOK FOR DIFFERENCES AND REASONS FOR THEM.
6. LOOK OVER YOUR RESULTS CAREFULLY.

The stories inside tell how students used these six steps to collect good data.

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USING THE SIX STEPS: BELTS FOR SALE

This story about Maria, Fred, and Betsy shows how they followed the six steps and collected good data.

Maria's class wants to raise a lot of money by making and selling belts. Her group is supposed to decide what sizes to make.

1. They Decide What They Want To Measure.

"Let's get down to business," says Maria. "We're supposed to decide what sizes of belts to make."

"We'll have to measure the kids in the school," Fred suggests.

"What are we going to measure?" asks Betsy.

"Waist sizes, naturally," Fred answers. "That will tell us how long to make the belts."

2. They Make Some Test Measurements.

"How do we measure waist sizes?" asks Betsy.

"With a tape measure, naturally," says Maria.

"A cloth one or a metal one?" asks Fred.

"Let's try out both," suggests Betsy. They then measure one another's waists with both cloth and metal tape measures. They find that the cloth tape measure is much easier to use and also more accurate since it lies flat against the waist.

3. They Plan How They Will Make Their Measurements.

"Let's write down how we will measure," suggests Maria. "Then we can try measuring kids in our class." Betsy and Fred agree. They write down some rules for measuring waist size.

- *Use a cloth tape measure.*
- *Don't measure anyone who fools around and makes his stomach bigger or smaller on purpose.*

"How accurate do our measurements need to be?" Maria asks as they look over the list. They look at Fred's belt and see that the length can be adjusted somewhat by using different holes. They measure and find that the holes are about 2 centimeters apart.

"If we measure in centimeters, it should be good enough," says Betsy. "Belts don't have to fit exactly."

"That's right," agrees Fred. "People can use the next hole if our measurement isn't exactly right."

The group reads "How To" Round Off Data. They agree to round off each measurement to the nearest centimeter.

4. *They Make Their Measurements Carefully.*

That afternoon Betsy and Fred watch while Maria measures the waist sizes of four students. Maria's results are:

MARIA

WAIST SIZES 10/21/77	
NAME	SIZE (CM)
JOHN	68
SUZY	60
KAREN	55
BILL	73

5. *They Repeat Their Measurements and Look For Differences.*

Betsy and Fred decide to measure the waist sizes of the same four students and compare results. Fred's results are almost the same as Maria's. But Betsy's results are different.

FRED

WAIST SIZES 10/21/77	
NAME	SIZE (CM)
JOHN	68
SUZY	61
KAREN	55
BILL	72

BETSY

WAIST SIZES 10/21/77	
NAME	SIZE (CM)
JOHN	78
SUZY	70
KAREN	65
BILL	83

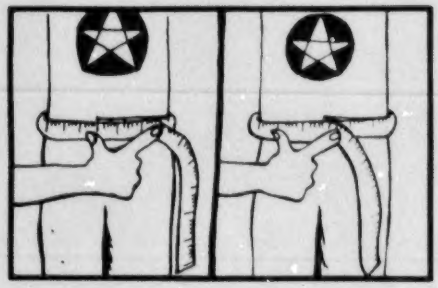
6. *They Look Over Their Results Carefully.*

"That's odd," Fred says, as he looks at the three charts. Betsy measured the same kids that we did. But her results are different. Her numbers are bigger."

"Did you follow the rules we wrote down about how we would measure?" Maria asks Betsy.

"Of course I did."

"Here's the tape measure," says Maria. "Show me how you measured. Measure my waist." Betsy puts the tape measure around Maria's waist. She begins to read the number. Then Fred sees the problem.



"You are measuring more than just around her waist," he says. "Why are you adding the extra length?"

"I'm measuring how long the belt should be," says Betsy.

"We can figure that out later when we make the belts," Maria says. "Right now we should measure waist size. Once around the waist and no more."

"Now we're ready to measure students in other classes," says Maria.

"But it'll take too long to measure everyone," objects Fred.

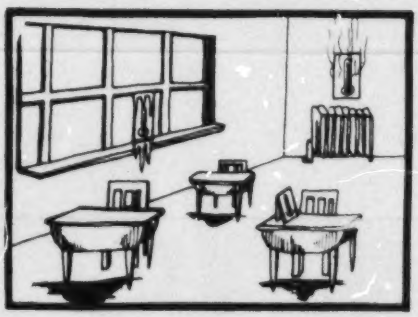
"Maybe we can measure a few big students, a few small ones, and some in between," Betsy suggests.

"I think they call that a sample," says Maria. "Let's find out how to choose a fair sample." Then they read "How To" Choose a Sample.

TESTING YOUR TOOL: TOO HOT/TOO COLD

Are you planning to measure with a trundle wheel?... balance?...thermometer?...some other tools? Some tools have scales on them. But the scales may not be right. Other tools may not have the scales on them. You will have to put a scale on them.

Sometimes your tool may not be working right. Before you start to measure, you should test your tool and make sure it will give you good measurements. You also have to find out the possible errors in using the tool. That is what students in this story do.



Bruce's classroom is usually hot in some places and cold in other places. Bruce, Jean, and Lee want to collect data on how warm it is in different spots in the classroom. They agree that they should put thermometers in certain places. They also agree to read them at certain times.

"What if the thermometers are different," wonders Lee. "We wouldn't be able to tell which place was the hottest."

"We'd better test all the thermometers to make sure that they all read the same temperature," says Bruce.

"How can we do that?" Lee asks.

"We'll have to put all the thermometers in the same place and see if they read the same," suggests Bruce.

"I've got an idea," says Jean. "Our science book says that stirred ice water is always 0 degrees Celsius. Why don't we put all the thermometers in a jar of ice water? If they all read 0 degrees Celsius, then we'll know they are O.K."

Bruce and Lee agree with Jean's idea. They get some ice from the lunchroom and put it in a jar with some water. They put the thermometers in the ice water. Every few minutes they stir the ice water. They leave the thermometers there for fifteen minutes.

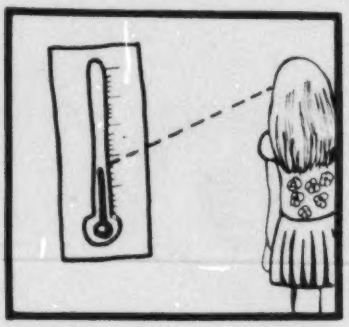
"That's funny," says Bruce. "All but one of the thermometers reads 0."

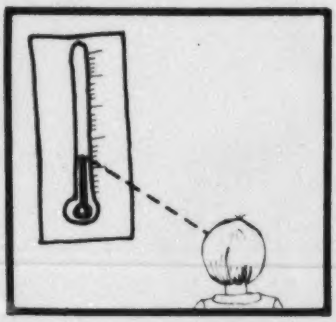
"That's not too bad," replies Lee. "We can use all of them except the one that doesn't read 0. We can see if we can fix it, but if we can't we'd better mark it 'NO GOOD'. Then we won't forget and use it."

Jean looks at the thermometers, too. "The temperatures on these three look like they are a little below 0, not 0," she says.

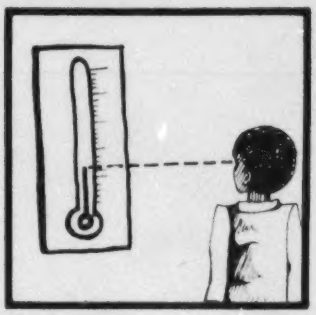
"That's because you're not looking straight at the thermometers. You're looking down at them," Bruce tells her.

"Then if I look up at a thermometer it will look like it's above 0?" asks Lee.





"That's right," says Bruce. "Our three readings can be different by 2 degrees. But I've been looking at this thermometer. It seems that if we all look straight at the thermometer the readings may be different only by 1 degree."



"Then the temperatures in different places in the room will have to be different by more than 1 degree to mean anything," Jean states.

Bruce, Jean, and Lee put the thermometers close together on a table to check whether they all read the same at room temperature. When they see that all the thermometers except the one marked "NO GOOD" are all right, they collect their data. They place all the thermometers in certain places in the classroom. They are careful to keep them always in exactly the same spots. Every two hours for the next two weeks Bruce, Jean, and Lee read the thermometers. They each read all the thermometers and keep separate records.

Before they show their data to the class, they compare their records. Together they have three readings for each time and place they measured. They use the middle of the three readings for each time and place.

Then Bruce, Lee, and Jean show the final temperature data to the class. They tell the class that they should consider only differences of more than 1 degree.

DECIDING HOW CLOSE TO MEASURE: TO THE NEAREST CENTIMETER

When you are collecting data, it's hard to decide how close to make your measurements. It's hard to decide how much to round off. Think about this before you start. Then it will be faster and easier to make your measurements.

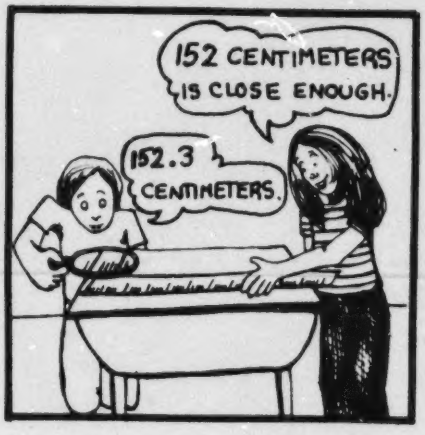
To do this you should:

1. *Decide how you are going to use your measurements. How close do they need to be for that?*

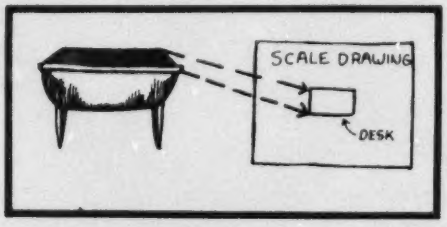
2. *Decide during your test measurement how accurate your measuring tools are and what errors you might make in using them.*

3. *Decide how close to make your measurements. Decide how much to round off your measurements.*

That's what Sam's group does in this story.



Sam's group is making a scale drawing of a room they want to use as a Design Lab. They have read "How To" Make a Scale Drawing. They know that they need to measure the room and the furniture they want in the room. They also know that in their scale drawing everything will be smaller than it really is.



"Let's decide on a scale before we start measuring," suggests Sam.

"Why?" asks Jesse.

"We're going to have to divide each measurement by a certain amount when we make our scale drawing," explains Sam. "If we know how much we are going to divide by, then we'll know how close our measurements have to be. We can measure things faster if we can round off our measurements."

Sue remembers a scale drawing she's seen and says, "It's hard to see closer than 0.1 centimeters on a scale drawing."

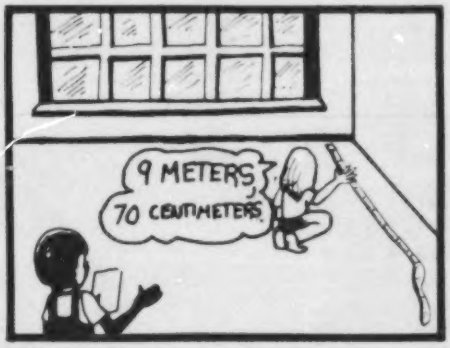
"That's right," says Sam. "Then we don't have to measure any closer than what 0.1 centimeter represents in the room.

"The room is about 10 meters long," says Bill. "Let's use big paper about 1 meter wide. That means that 1 meter on the paper represents 10 meters in the room."

Sue adds, "And 1 centimeter on the paper represents 10 centimeters in the room."

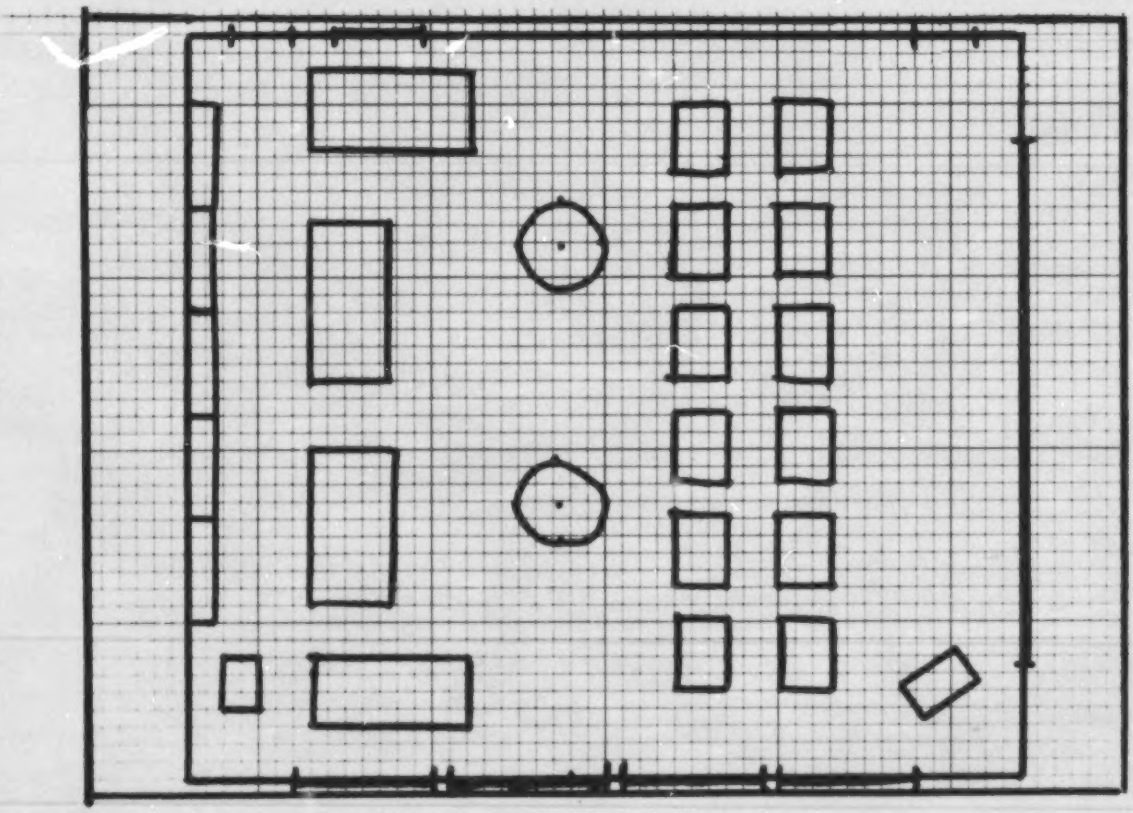
"Now I see," says Jesse. "Our measurements don't have to be closer than 1 centimeter to show as 0.1 centimeters on paper."

"We can round off each measurement to the nearest centimeter as we measure," says Sam. "That will make it a lot faster."



Sam, Sue, Jesse, and Bill measure the room and the furniture. They measure everything to the nearest centimeter. Later they divide by 10 to find out how big to make the things on the scale drawing.

When the group shows the drawing to the class, they explain how they did it. They say that the drawing shows that some furniture may not quite fit. But they are not sure. To find out, they plan to measure that furniture more closely.



LOOKING OVER YOUR DATA: MONSTER HAMSTERS

After collecting your data, it is a good idea to look at it closely. One number may look very different from the others. You will then have to figure out what happened and decide what to do about it. Maria's group did that in BELTS FOR SALE. Sometimes your data won't make sense when you look at them closely. In this story Wayne, Liz, and Ray find that all their data are strange.

"Classes will be visiting our school zoo in a few days," Wayne says to Liz and Ray. "We have to tell them about the animals."

"Then we'd better find out how much each animal weighs," Ray says.

"I'll get the classroom scale," says Liz. She does and then they talk about how they will weigh the animals. They decide that all three of them will check each weight. They make up data charts.

They weigh the four hamsters, one at a time. They write their data on a chart.

OUR HAMSTERS' WEIGHT NOV. 20

NAME	WEIGHT (KILOGRAMS)
ABBIE	62
BOXIE	49
CANDIE	54
DOBIE	58

"Now let's weigh the gerbils," Ray says.

"Hold on," says Wayne. "I want to look at these numbers."

"They are all around 50 or 60," Ray says. "That looks right."

Suddenly Liz starts to laugh. "What's so funny?" Wayne asks.

"I was just picturing a 60-kilogram hamster," she says. "I weigh only 45 kilograms."

"I guess we read the scale wrong," Wayne says.

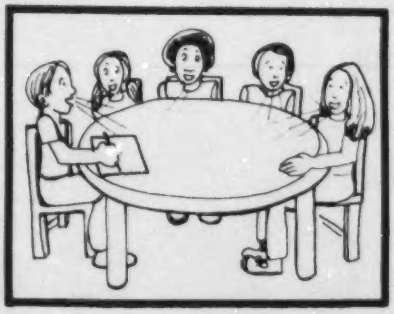
"Yes," says Ray, looking at the scale. "It should be grams not kilograms."

"That's more like it," Liz chuckles.

They change their data chart and then weigh the gerbils.

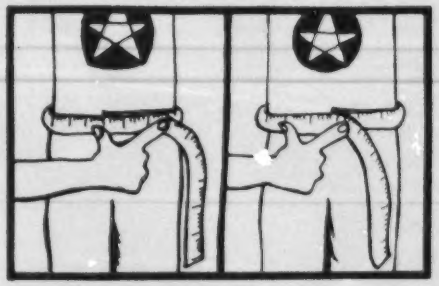
COLLECTING YOUR OWN DATA

So far you have read stories about children collecting data. How should YOU collect YOUR data? What should you do first? Here is a checklist. It will help.



☆ 1. DECIDE WHAT YOU WANT TO MEASURE.

- Talk with your group about what you want to find out.
- Decide exactly what data or measurements you need.



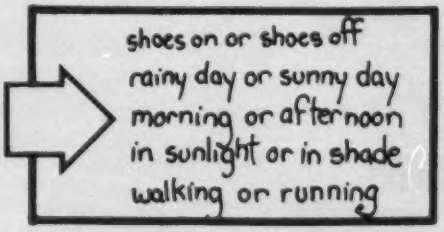
☆ 2. MAKE SOME TEST MEASUREMENTS.

- Try out different measuring tools.
- Think about how accurate each tool is.
- Think about what errors you might make in using each tool.
- Decide which tool is best to use.

☆ 3. PLAN HOW YOU WILL MAKE YOUR MEASUREMENTS.

- Decide exactly what each person is going to do.
- Draw a picture to show how you will do the measuring.
- Think about the things that can make your measurements look different.

  Look at the things in the box.
  Could any of them change your measurements?
  Can you think of other things that can change your measurements?
  Decide how to keep those things the same.



- Decide how close your measurements need to be. How will you round off your measurements? You can read "How To" Round Off Data.

☆4. MAKE YOUR MEASUREMENTS CAREFULLY.

- Test your measuring tool first.
- Decide how close your tool will measure.
- Do your measurements carefully. Round off as much as you decided.

☆5. REPEAT YOUR MEASUREMENTS.
LOOK FOR DIFFERENCES AND REASONS FOR THEM.

- Have another person or group do the same measurement again.
- Compare the measurements. Are they almost the same? Are they different? If the measurements are very different, think about what could have happened.
- Do the measurements again if you find that something went wrong.

☆6. LOOK OVER YOUR RESULTS CAREFULLY.

- Do your data help you solve your problem? If not, then maybe you measured the wrong thing. Or maybe you need to do something to your data. You can find out by reading "How To" Tell What Your Data Show.
- Do any numbers look very different from the others? If so, then try to figure out why. You may have to do these measurements over. Or you may have to cross them out.
- Do your results make sense? Are all the measurements too big or too small? If so, then try to figure out what went wrong.

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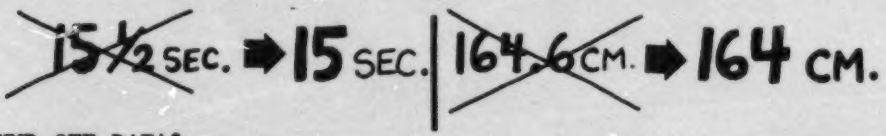
"HOW TO"

ROUND OFF DATA

WHAT IS ROUNDING OFF DATA?

When you round off data you use only those numbers in a measurement that are necessary. For example, you might use--

- 15 seconds as a time to cross a street instead of 15 1/2 seconds,
- 165 centimeters as a height of a student instead of 164.6 centimeters.



WHY ROUND OFF DATA?

When you round off data as you measure--

- it makes it quicker and easier to make your measurements. You don't spend time trying to see fractions of seconds or centimeters. You round off to the big marks on the scales.
- it makes it easier to add, subtract, multiply and divide your data.
- all your data will have the same amount of accuracy.

You have to be careful in rounding off data. You can round off too much.

HOW CAN YOU KNOW HOW MUCH TO ROUND OFF DATA?

To find out how much you can round off data, you have to think about two things. They are:

1. how accurate you want your measurements to be
2. how accurate your measurements can be.

The stories in this booklet tells you how students rounded off their data as they measured. Read the stories. They will help you decide how to round off your data.

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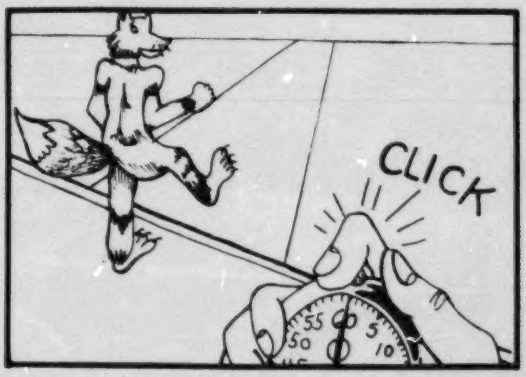
ROUNDING OFF TIMES: WALK DON'T RUN

Many of the measurements you make are measurements of time. You may need to measure--

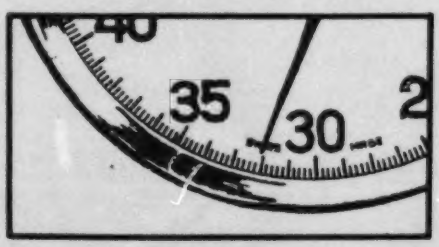


- *the time it takes to cross a street or run a certain distance*
- *the time it takes a car to travel a certain distance*
- *the time students spend waiting in the lunch line*
- *the time it takes to walk to school or to find a certain place in the school*
- *the lifetime of batteries*
- *the time since seeds were planted*

You will want to use different units of time--seconds, minutes, hours, or days. You will have to decide in each case how close your measurements have to be. You will have to decide how much you can round off. That's what Joe, Marcia, and George do in this story.

Joe's class is trying to do something about the street crossing in front of their school. Many students have to run across the street because the traffic is so heavy in the morning. Joe, Marcia, and George decide to find out how long it takes students to cross the street when they don't run. They practice using a stopwatch and see that the stopwatch shows times in seconds and fifths of seconds.

"How close do our measurements have to be?" asks Marcia. "Do we use just the big marks for seconds, or do we use the little marks for fifths of seconds?"



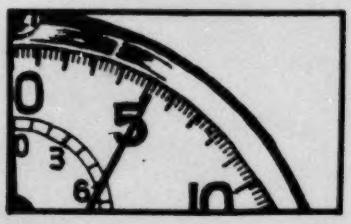
"Let's go out and time how long it takes each of us to cross the street," suggests Joe. The others agree.

They try measuring the time it takes George to cross the street. They see that they can't press the button on the stopwatch at exactly the time he steps off the curb. They can't press it again at exactly the time he is at the other side of the street. They decide that they might have been wrong by one- or two-fifths of a second.

"I think the police will be interested in seconds, not anything smaller," says George.

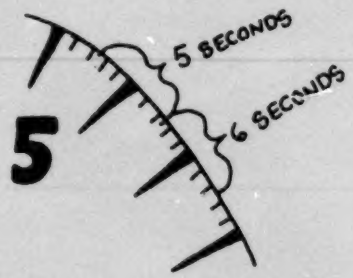
"Let's use only the big marks for seconds," suggests Marcia.

"That's O.K.," says George. "But which big mark should we use--the one before where the pointer is, or the one after it?"



"If it's less than halfway to the next big mark, we should use the big mark before the pointer," says Joe.

"Then if it's more than halfway, we use the big mark after the pointer," adde Marcia.



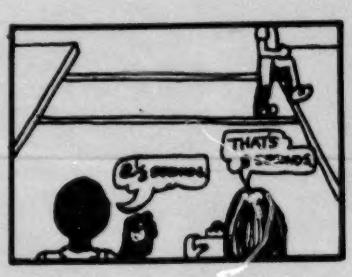
Joe, Marcia, and George describe their plan to the teacher. She says that it's a good plan. She explains that they are rounding off to the nearest second.

The teacher asks them what they are going to do with their measurements. Marcia replies that they are also going to measure the times between cars. Then they will compare their measurements of the crossing times with the times between cars. They want to show that they need a WALK sign at the crossing in order to be able to cross safely.

"We'll have to round off the times between cars to the nearest second, too," says George. "That way we can compare the two sets of data better."

In this story, the students rounded off the time to the nearest second. In other cases such as timing a race you may want to measure more closely. You may want to use fifths of seconds.

When you measure the time students wait in the lunch line, you may want to round off your times to the nearest minute. In other cases you may want to round off to the nearest 5 minutes, the nearest half-hour, the nearest hour, the nearest 3 hours, etc.



ROUNDING OFF DISTANCES: HANG IT HIGH/HANG IT LOW

Many of the measurements you make are measurements of distance. You may need to measure--

- *the height of plants to find out how fast they are growing*
- *the eye-level height of students to decide how high to put posters*
- *the length and width of a room and the furniture in it to make a scale drawing*
- *the length and width of a playground*
- *the length of a bicycle path*

You will want to use different units for distance--millimeters, centimeters, or meters. You will have to decide in each case how close your measurements have to be. You will have to decide how much you can round off your measurements.

This story and the next two stories tell how students decided how much they could round off their measurements of distance.

Sue, Jean, and Betsy want to put up posters in the hallway. They want the posters to be high enough so that tall students can read them easily. They also want them low enough so that short students can read them easily. They decide to measure the eye-level heights of a sample of students in the school. They first measure the eye-level heights of a few students in their class.

"Do we use the big marks on the meter stick or the small marks?" asks Sue.

"It will be faster if we use only the big marks and forget about the small marks," says Jean. "Our measurements will be close enough."

"The big marks show centimeters. Our measurement could be wrong by almost a whole centimeter," says Betsy.

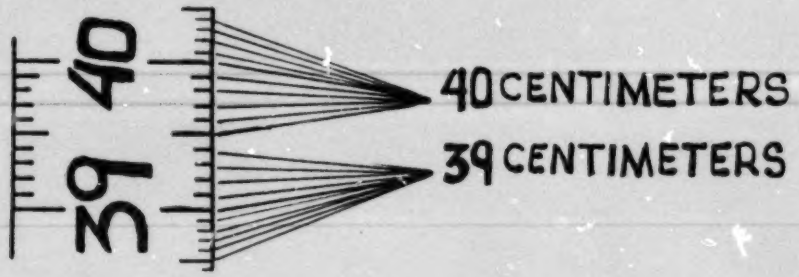
"We can round off measurements that are less than half to the centimeter mark below the measurement," suggests Sue. "Measurements more than half can be rounded off to the centimeter mark above the measurement. That way our measurement would be wrong by no more than a half-centimeter."

"What do we do if the measurement is exactly half?" asks Jean.

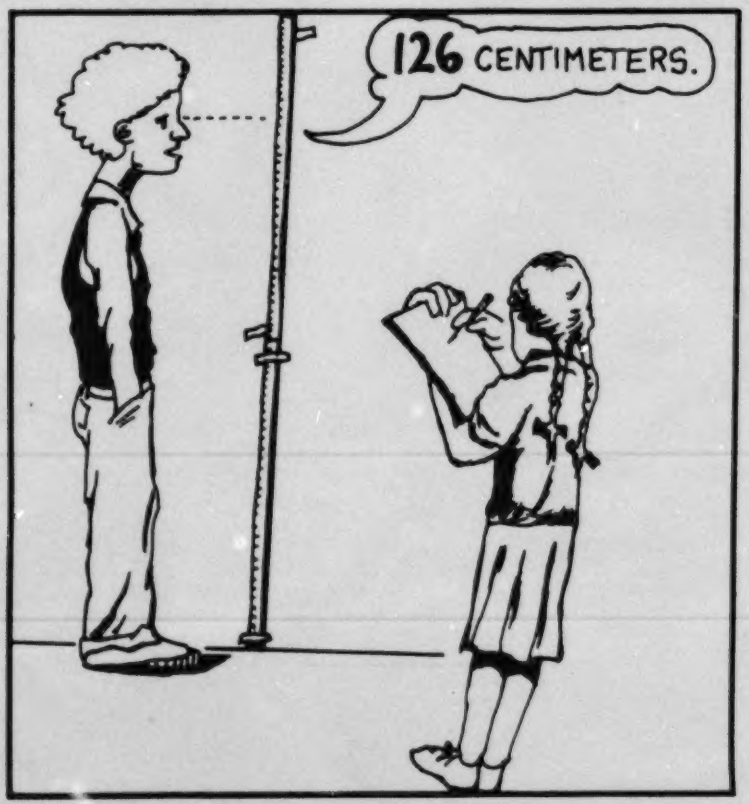
"I'll bet that doesn't happen often," says Sue. "You're just not looking closely enough."

"But it can happen sometimes," insists Jean. "What do we do then?"

"If we're sure it's exactly half, we can round off to the centimeter mark above the measurement," says Sue. "As long as we do it the same way each time, it should be O.K."



"The meter stick we're using is accurate," says Jean. "But we'll have to be careful how we do the measuring. Otherwise, we could be wrong by a whole centimeter."



ROUNDING OFF DISTANCES: SUN OR SHADE

In the last story Sue, Betsy, and Jean measured the eye-level height to the nearest centimeter. In this story John and Mary Lou find that they can't round off that way.

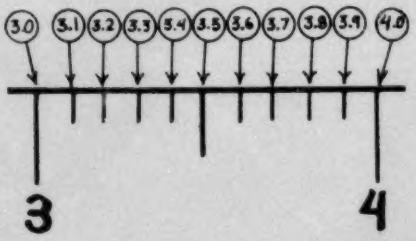
John and Mary Lou are doing an experiment to find out whether their plants grow better in sunlight or in shade. They plan to measure the height of their plants each day. On the first day they record the height of two of their plants as 3 centimeters.

"But my plant looks taller than yours!" says John. "Why are we putting them both down as 3 centimeters?"

"That's because we're measuring to the nearest centimeter," answers Mary Lou. "It's faster than measuring closer."

"We can't ignore small differences in height in our experiment," says John. "We'd better not round off to the nearest centimeter even though it takes longer to measure. We can put down centimeters and the small marks between them. Let's ask the teacher how to do it."

The teacher tells John and Mary Lou they can record the small mark for the measurement of one of the plants by putting down 3.2 centimeters. He explains that the number after the decimal point stands for the number of small marks. The distance between the small marks is 1/10 the distance between the centimeter marks.



John and Mary Lou are also told that the small marks indicate millimeters. They can call their measurement 32 millimeters if they want to. Because they can see which small mark the height is closer to, they are measuring to the nearest millimeter.

ROUNDING OFF DISTANCES: HOW FAR DOWNTOWN/HOW FAR ACROSS THE STREET

In the last two stories, the students measured short distances. They rounded off to the nearest centimeter when they measured eye-level heights. They rounded off to the nearest millimeter when they measured plant heights. In this story, students have a different problem. They are measuring the length of a bicycle path and the distance across a street with a trundle wheel they have built.

Martha, Jean, and Paula are using a trundle wheel to measure the length of a bicycle path from their school to a shopping center. The dirt path is getting bumpy and rutty. They want to find out how much it would cost to pave the path.

"Our trundle wheel clicked 272 times and we turned it more before we came to the end of the path," says Martha. "Do we add on the distance it went after the last click?"

"I don't think that short a distance would make any difference," says Paula. "Even if the distance was almost a full turn, that's less than a meter. All the bumps in the path made at least that much difference."

"And we aren't sure that our trundle wheel is exactly a meter around," says Jean. "If the distance around is wrong by just 1/2 centimeter, it would make a big difference in 272 turns."

"It would make a difference of 136 centimeters," says Paula. "That's 1.36 meters. It's more than a meter. I'm sure that we don't have to add on any distance less than a full turn."

"We studied percentages in class yesterday," says Martha. "Just to make sure, let's figure out what percentage the extra distance is if it were a full turn." She writes on a sheet of paper.

$$\frac{1}{272} \times 100\% = 272\overline{)100} = .367\%$$

$$\begin{array}{r} .367 \\ 272\overline{)100.000} \\ 816 \\ \hline 1840 \\ 1632 \\ \hline 2080 \\ 1904 \end{array}$$

"That's less than a 1/2 per cent difference," says Martha. "If it costs $300 to pave the path, then the extra distance would cost less than $1.50."

"That settles it," says Paula. "We'll count only full turns. Our measurement doesn't have to be more accurate than that.

The next day Michael and Bob use the trundle wheel to measure the distance across the street. They ask Martha and Paula if they can use only full turns, too.

"How many full turns did you measure?" asks Martha.

"We counted 8 clicks," says Michael. "That's 8 full turns. But we went almost a full turn after the last click."

"Do we count that extra distance?" asks Bob.

"Let's calculate the percentage if the extra distance is almost a full turn," suggests Martha. She writes:

$$\frac{1}{8} \times 100\% = 8\overline{)100} = 12.5\%.$$

"That's over 12%," says Martha. "That's a large percentage. A difference of one turn was less than 1/2% when we measured the bicycle path.

"I guess that we'll have to measure the extra distance and add it on," says Bob.

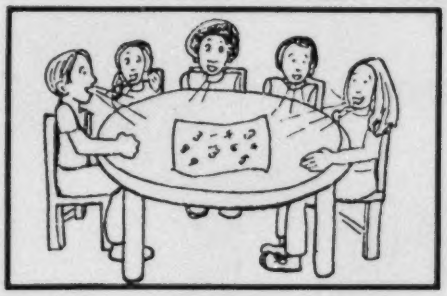
In these two stories the children discovered that an error of 1 meter is a larger percentage error when a short distance is measured than when a large distance is measured. They decided that they could round off more for a large distance than for a short distance.

HOW TO ROUND OFF YOUR DATA AS YOU MEASURE

The stories have told you how other students have rounded off their data. But you may have measured different things. How should YOU round off YOUR data? Here is a list of things you can watch out for. Read the list and then decide how much you should round off your data as you measure.

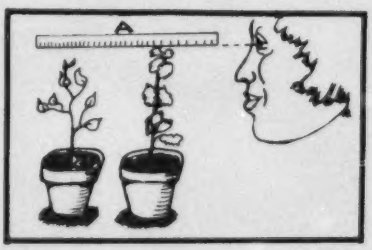
1. DECIDE HOW ACCURATE YOU WANT YOUR MEASUREMENTS TO BE.

   Talk with your group about how you are going to use your measurements.

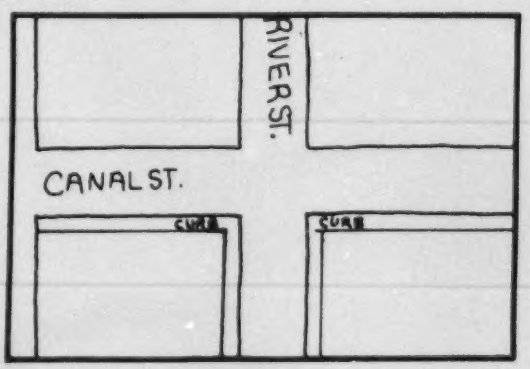


Are you trying to find out how high to have posters, how high to make a table you are constructing, or how big to make belts you are manufacturing? Decide what is the biggest error that you can have that won't make any difference.

Are you comparing two things? Are you comparing the heights of two plants, or times that will be recorded before and after a change has been made. Differences between two things may not show up if your measurements aren't accurate. Decide how big a difference you need to have.



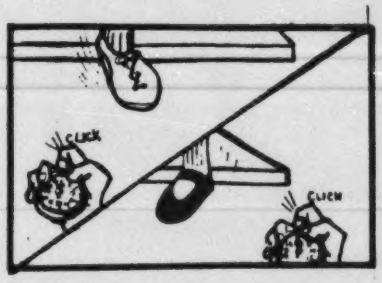
Are you making a scale drawing? What is the scale? How accurate your measurements have to be depends on the scale. Decide first on your scale and then you will know how accurate your measurements need to be.



☆ 2. DECIDE HOW ACCURATE YOUR MEASUREMENTS CAN BE.

Talk with your group about the errors in the instrument you are using. No instrument is absolutely accurate. Every instrument has certain errors in it.

Talk with your group about what errors you might make in doing the measuring. Sometimes you can't avoid making some errors. If you are careful, you may make only small errors.



☆ 3. DECIDE HOW MUCH YOU CAN ROUND OFF.

If your measurements <u>don't</u> have to be very accurate, you can round off quite a bit as you measure.

If your measurements have to be accurate, you can't round off much.

If the instrument you are using and the way you measure have large errors, you can round off quite a bit.

If the instrument you are using and the way you measure have only small errors, you don't have to round off much.

Remember: Round off as much as you can. It makes measuring quicker and easier to do.

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"HOW TO"

RECORD DATA

WHY RECORD DATA?

It's easy to forget things. Suppose that you measure the height of everyone in your class today. Tomorrow you will probably not remember all the numbers. But if you write down the measurements on a piece of paper, then all you have to do is look at the paper whenever you need to remember your data: so you or someone else can read it–tomorrow, next week, or next year.

WHY USE CHARTS?

Charts make it easier to see data. Look at these two ways of writing the weights of four hamsters.

> We measured the weights of four hamsters. Bobo weighs 137 grams. Jam weighs 142 grams. Bimbo's weight is 129 grams. Zorro weighs 148 grams.

WEIGHT OF HAMSTERS	
NAME	WEIGHT (grams)
Bobo	137
Jam	142
Bimbo	129
Zorro	148

It is easier to read the chart. It is easier to compare numbers on the chart.

WHAT'S INSIDE

Step–By–Step: Making a Data Chart.....pages 2,3
Using a Chart to Count Things.....pages 4,5
Making Charts with 3 Columns.....page 6
Making Charts with 4 Columns.....page 6
Writing Measurements on a Drawing.....page 6
Making a Confusion Chart.....page 7
Making Your Own Data Chart.....page 8

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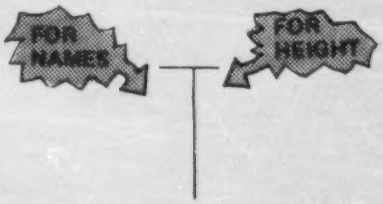
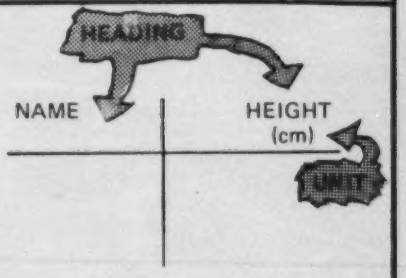
MAKING A DATA CHART

How do you decide what type of chart to make? What should be on your chart? To begin to find out, let's suppose that you are going to measure the heights of five people in your class. Here is how you might go about making a data chart to record the heights.

1 HOW MANY COLUMNS should the chart have? To record peoples' heights, you should make a chart with TWO columns. One column is for names of people. The second column is for their heights.



2 PUT A HEADING on each column to tell what is in the column. If the column is a measurement–like height, weight, time, and temperature –tell what unit you used. That way someone will know whether 100 means 100 inches or 100 centimenters or 100 meters.

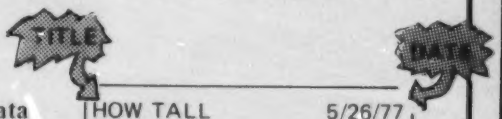


3 FILL IN a column if you can. If you know who you are going to measure, fill in their names ahead of time.

NAME	HEIGHT (cm)
JOEY	
SUE	
SALLY	
RAY	
BETTY	

4 WRITE A TITLE so someone can see quickly what the data in the chart is all about.

5 WRITE THE DATE on which the measurements are taken.



HOW TALL WE ARE	5/26/77
NAME	HEIGHT (cm)
JOEY	
SUE	
SALLY	

6 COLLECT YOUR DATA Write down each person's height next to his or her name.

HOW TALL WE ARE	5/26/77
NAME	HEIGHT (cm)
JOEY	145
SUE	
SALLY	
RAY	
BETTY	

2

MAKING A DATA CHART (continued)

7 **DESCRIBE HOW YOU COLLECTED YOUR DATA** Someone–maybe you–may want to check your data by collecting it again. Or, you or someone else may want to add to your data. In either case, written instructions are needed to collect the new data in the same way.

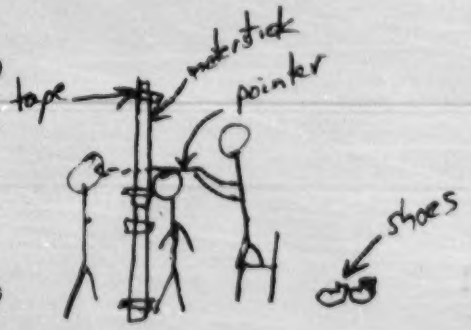
When you describe how you collected your data, you should write—

- what measuring instruments you used
- how the measurements were made
- how the measurements were checked
- how the measurements were rounded off
- who was in your group

Here is how a group of students who measured the heights of five children might describe how they collected their data:

How we measured Height:

We measured the height of five students in our class. We taped 2 meterstiks to the wall, one on top of the other. We used a pointer to help us read straight across from the top of someone's head to the meterstiks (see the drawing). John held the pointer. Sue looked at the height. Bob checked her answer. If they agreed, Bill wrote down the number on the chart. If they didn't agree, Sam looked at the height and said who he thought was right. Before we measured a person, we asked him to take off his shoes. When we measured, we rounded off to the nearest centimeter. The people in our group were: John S, Sue S, Bill S, Sam E, and Bob X.



USING A CHART TO COUNT THINGS

AN EXAMPLE

Suppose you want to find out which drink people in your grade like most. You might set up a test. Each person would be blindfolded. He would taste the drinks and tell you which one he liked best. You could record the results on a chart like this →

FAVORITE DRINK 5/23/77	
DRINK	HOW MANY CHOSE IT
A	
B	
C	
D	

HOW TO RECORD ON A TALLY CHART

Every time someone votes for drink A, put a TALLY MARK in the space next to drink A. Every time someone votes for drink C, you put a tally mark next to drink C.

Suppose you have tested 10 people. Let's say that 3 people voted for drink A, 1 for drink B, 4 for drink C, and 2 for drink D. Your chart would look like →

FAVORITE DRINK 5/23/77	
DRINK	HOW MANY CHOSE IT
A	///
B	/
C	////
D	//

MAKING LARGE NUMBERS EASY TO COUNT

Suppose part of your chart looked like this →

A	////////////////
B	

It's hard to count so many marks that are so close together. You can make it easier by marking bundles of five. Draw a slash (- or ~) for every fifth mark. 𝍸 or 𝍸

Using the bundle method makes it faster to count the number of tally marks.

Regular method Drink A ////////////////

Bundle method Drink A 𝍸 𝍸 𝍸 //

Here's how the results of the whole test might look after you tested 45 people: →

FAVORITE DRINK 5/23/77	
DRINK	HOW MANY CHOSE IT
A	𝍸 𝍸 𝍸 // (17)
B	//// (4)
C	𝍸 //// (9)
D	𝍸 𝍸 𝍸 (15)

4

USING A CHART TO COUNT THINGS (continued)

WRITING THE TIME PERIOD ON YOUR CHART

Suppose you were counting how many cars, trucks, buses, and bicycles passed by the school. You could use a tally chart that might end up looking like this

VEHICLES PASSING OUR SCHOOL 5/27/77		
VEHICLES	NUMBER	
CARS	𝍸 𝍸 𝍸 𝍸	(40)
TRUCKS	𝍸 𝍸 𝍸 ///	(18)
BUSES	////	(4)
BICYCLES	𝍸	(5)

Was there a lot of traffic? You can't tell from the chart. If you had counted for 2 minutes, you would say there was a lot of traffic. But if you had counted for an hour, then you would say there was NOT a lot of traffic.

When you count something for a certain period of time, write the period of time on your chart. It may look like this

VEHICLES PASSING OUR SCHOOL 2 pm–2:15 pm Thursday 5/27/77	
VEHICLES	NUMBER
CARS	

Include the STARTING TIME and the FINISHING TIME.

GROUPING YOUR DATA

You can sometimes use a tally chart to help you see data that you have already collected. Suppose you measured the heights of everyone in your class. The chart might show 25 names and 25 heights. It could be long, and hard to read. A tally chart might help.

You could set up a tally chart to show how many children are between 110 and 115 centimeters tall, how many are between 115 and 120 centimeters tall, and so on. The tally chart might look like this

HEIGHTS IN OUR CLASS 12/4/78		
RANGE (cm)	NUMBER OF CHILDREN	
110–115	𝍸 /	(6)
115–120	𝍸 𝍸 ///	(13)
120–125	𝍸 𝍸 𝍸 /	(16)
125–130	𝍸 𝍸 //	(12)
130–135	///	(3)

When you describe how you collected your data, you should say whether 115 is included in the 110-115 group or in the 115-120 group.

HOW TO MAKE A BAR GRAPH HISTOGRAM tells more about grouping data.

MAKING CHARTS WITH THREE COLUMNS

AN EXAMPLE

Some charts need three columns. Suppose you want to find out two things about a group of students in your class. Let's say you measure height and weight. You could record your data on a chart like this

OUR HEIGHTS AND WEIGHTS		5/30/77
NAME	HEIGHT (cm)	WEIGHT (kg)
JOHN BOB SALLY MAGGIE TOM BETTY		

MAKING CHARTS WITH FOUR COLUMNS

AN EXAMPLE

Some charts need four columns. Suppose your class runs a school store, where children can buy pencils, notebooks, and other supplies. You may want to keep track of what things are sold and how much money you take in. You might make a chart like this

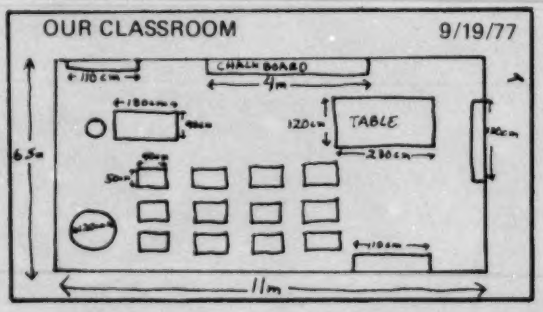
SALES ON TUESDAY			5/3/78
ITEM	PRICE	HOW MANY SOLD	TOTAL AMOUNT

If someone bought 3 pens and each pen cost 15¢, you would record the data like this

SALES ON TUESDAY			5/3/78
ITEM	PRICE	HOW MANY SOLD	TOTAL AMOUNT
PEN	15 ¢	3	45 ¢

WRITING MEASUREMENTS ON A DRAWING

Sometimes you can use a drawing instead of a chart to record your data. Suppose you are measuring the length and width of things in your classroom. You can write down your measurements on a drawing or chart like this:



MAKING YOUR OWN DATA CHART

In this pamplet you have seen several kinds of charts.
Which kind of chart is best for the data you are collecting?
Should your chart have two columns? Three columns? Four columns? More?
Here's how to find out.

FIRST Find out how many KINDS OF DATA you will be collecting.
Look at the kinds of data shown here

SOME KINDS OF DATA

days dates months names of people
brands flavors rooms classes
cost
height weight
time temperature
distance
scores area
number of days
scores
number of cars
number of accidents
amount of food
volume yes answers
percentage of yes answers

Which kinds of data will you be collecting? Write them in the spaces below, or write in your notebook if you are not to write in this book.
Are you collecting kinds of data that are not shown in the box above? Write them down too.

MY CHART WILL HAVE THESE KINDS OF DATA

_____ _____ _____ _____ _____ _____ _____
_____ _____ _____ _____ _____ _____ _____
_____ _____ _____ _____ _____ _____ _____

SECOND Make one column for each kind of data you have listed.
If you are collecting **2** kinds of data, make a chart with **2** columns.
If you are collecting **3** kinds of data, make a chart with **3** columns.
If you are collecting **4** kinds of data, make a chart with **4** columns.

NOW YOU CAN FINISH YOUR DATA CHART

Put a heading on each column
Fill in any columns that you can
Write a title for the chart
Write the date on which you collect your data
Collect your data write it on your chart
Describe how you collected your data.

If YOU WANT TO KNOW MORE about these steps, study pages 2 and 3

7

CONFUSION CHART

Suppose you wanted to find out whether people could really taste the difference between two products, like Coke and Pepsi. You could run a CONFUSION TEST and record your data on a CONFUSION CHART. It looks like this

CONFUSION CHART 2/8/78			
	GUESSED		
		COKE	PEPSI
GIVEN	coke		
	pepsi		

HOW TO RUN A CONFUSION TEST

Let's say that Joe is the first person you will test. Put a blindfold on Joe and then give him a glass of Coke or Pepsi to taste. But don't tell him which it is. Let him guess.

Here's how you would record Joe's guess:

If you gave him Coke and he guessed Coke, put a mark in this box.

If you gave him Coke and he gussed Pepsi, put a mark in this box.

If you gave him Pepsi, and he guessed Coke, put a mark in this box.

If you gave him Pepsi, and he guessed Pepsi, put a mark in this box.

		GUESSED	
		COKE	PEPSI
GIVEN	coke		
	pepsi		

Next, you would repeat the test with another person.

After you test everyone you want to test, your chart may look like this

CONFUSION CHART 2/8/78			
	GUESSED		
		COKE	PEPSI
GIVEN	coke	7	15
	pepsi	13	5

28 guessed wrong

12 guessed right

You can tell from the chart that–

- 7 people knew Coke when they tasted it
- 5 people knew pepsi when they tasted it
- 13 people thought Pepsi was Coke
- 15 people thought Coke was Pepsi

You could also say that–

- 12 people could taste the difference
- 28 people could NOT taste the difference

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"HOW TO"

DO AN EXPERIMENT

DO YOU WANT TO FIND OUT--

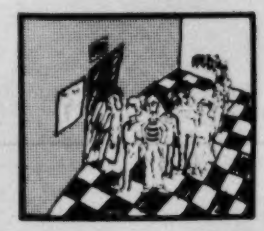
WHETHER ONE THING IS BETTER THAN ANOTHER?

You may want to find out which kind of paper towels or potato chips to buy or which brand of string is stronger.

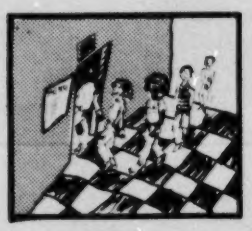
WHETHER A CHANGE THAT YOU HAVE MADE HAS IMPROVED SOMETHING?

You may want to find out whether a new lunch schedule has made the lunch line move faster or whether advertising has increased sales at your school store.

BEFORE



AFTER



WHETHER ONE WAY OF DOING SOMETHING IS BETTER THAN ANOTHER WAY?

You may want to find out whether plants grow better in sunlight or under lights or whether you learn words better by spelling them out loud or writing them down.

YOU CAN DO AN EXPERIMENT TO FIND OUT THESE THINGS.

But it is easy to make mistakes when you do experiments. You can get wrong answers and make wrong decisions. In order to do a good experiment you first need to know how to make good measurements. You can read "How To" Collect Good Data to find out about this. Then, you need to know how to plan your experiment. This booklet tells about some steps to follow in doing an experiment.

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HOW TO DO YOUR EXPERIMENT	11

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STEPS FOR A GOOD EXPERIMENT

☆1. DECIDE WHAT TO MEASURE AND HOW TO MEASURE IT.

☆2. MAKE A TEST MEASUREMENT IF YOU CAN.

☆3. KEEP EVERYTHING THE SAME EXCEPT THE ONE PROPERTY YOU ARE TESTING.

☆4. REPEAT YOUR MEASUREMENTS SEVERAL TIMES.

☆5. THINK CAREFULLY ABOUT THE DATA.

☆6. DECIDE WHAT THE EXPERIMENT TELLS YOU.

REMEMBER: You Should Change Only One Thing at a Time When You Do An Experiment.

A FAIR COMPARISON

Sometimes you may need to compare measurements. Suppose you have two brands of paper towel. Let's say you want to find out which brand lasts longer when you scrub. You can measure each brand. Then you can compare them. But you have to collect good data and also pay special attention to certain things. That's what Lucy and her group do in this story.

☆*1. They Decide What To Measure and How To Measure It.*

Lucy's class wants to find the best brand of paper towels. The students have done some tests. Squeezy and Fluffy are the two brands that have come out ahead most of the time.

Lucy, Juan, and Rick are in charge of finding out whether Squeezy or Fluffy lasts longer when you scrub.

"How can we measure how long a paper towel lasts?" Lucy asks.

"We can scrub it on a piece of wood until it tears," Juan says. "And we can count how many scrubs it takes to tear it."

"Good idea!" says Rick.

☆ 2. *They Make a Test Measurement.*

They each scrub with a paper towel. They then write down these rules for measuring.

Soak one sheet of paper towel in water.
Fold it in half.
Fold it in half again to make a rectangle.
Scrub a flat, smooth piece of wood with the towel.
Each time you rub back and forth, it counts as one scrub.
Count the scrubs.
Stop when your fingers go through the paper towel and touch the wood.

☆ 3. *They Keep Everything the Same Except the One Property They Are Testing.*

Lucy, Juan, and Rick are about to get the materials for the test. Then Juan thinks of something.

"We may not always scrub the same way," he says. "I can make some long strokes and some short strokes."

"We can fix that," Rick says. "We can draw two lines on the piece of wood." Then Rick adds a rule to the list.

Scrub from one line to the other, so each scrub is the same length.

"That's good," Juan says. "But there is another problem. We don't all press down the same way when we scrub. I may scrub harder than you or Lucy."

"One person will have to do all the scrubbing," Lucy says.

"I'll do it," says Rick. "Let's get started."

They begin to get the things they need. "I think Squeezy will win," says Rick.

Lucy disagrees. "I think Fluffy will win," she says.

"Whoops," Juan says to Rick. "The comparison won't be fair. You are going to scrub harder with Fluffy just so Squeezy will win."

"No, I won't," Rick says.

"Let's make sure of that," Lucy says. "Here's my idea. Rick, we will hand you the paper towels. They will be all ready to test. But we won't tell you which is which. Then the test will be fair."

"O.K.," Rick agrees. They begin the testing. They do five measurements using Fluffy towels. And they do five measurements using Squeezy towels. They record the results.

Number of Scrubs Rick 10/4		
Test	FLUFFY	SQUEEZY
#1	12	8
#2	14	7
#3	11	5
#4	15	12
#5	12	9

"Fluffy lasts longer," says Lucy.

☆4. *They Repeat the Measurements Several Times.*

"Let's do it again to check our results," Juan says. "This time I'll scrub."

They repeat their measurements. Each brand is scrubbed five times. Then they measure again. This time Lucy scrubs. Then they look at their results.

Number of Scrubs Rick 10/4		
TEST	FLUFFY	SQUEEZY
#1	12	8
#2	14	7
#3	11	5
#4	15	12
#5	12	9

Number of Scrubs Juan 10/4		
TEST	FLUFFY	SQUEEZY
#1	14	10
#2	11	11
#3	10	9
#4	11	9
#5	12	7

Number of Scrubs Lucy 10/4		
TEST	FLUFFY	SQUEEZY
#1	18	12
#2	16	14
#3	14	10
#4	16	12
#5	12	9

☆5. *They Think Carefully About the Results.*

"Fluffy lasts longer," Rick says. "My data prove it."

"Let's make sure that we each got the same results," suggests Lucy. "We can find the median for each set of five tests." (She has read "How To" Compare Two Sets of Data.)

"O.K.," says Rick. "But I still think that Fluffy won."

They each find the medians from their data and make a chart of medians.

MEDIAN NUMBER OF SCRUBS		
PERSON	FLUFFY	SQUEEZY
RICK	12	8
Juan	11	9
Lucy	16	12

"You see!" says Rick. "Fluffy turned out best for each of us."

☆6. *They Decide What the Experiment Tells Them.*

"I had a difference of only 2 strokes between Fluffy and Squeezy," remarks Juan. "That isn't much."

"But both Lucy and I had a difference of 4 strokes," Rick answers. "That's a lot when the biggest number of strokes was only 18."

"Let's tell the class that Fluffy is a little better," suggests Lucy. "If Fluffy were a lot better, there would be more of a difference."

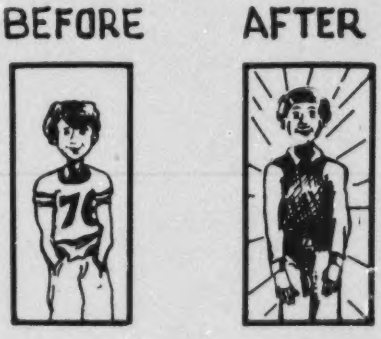
"Anyway," says Rick, "no one can say that our test wasn't fair."

BEFORE AND AFTER

In A FAIR COMPARISON, *the students measured two brands. They measured them at the same time. Sometimes you have to measure the same thing at different times.*

Suppose you make a change in your classroom or your lunchroom or your playground. And suppose you want to know if your change makes things better.

You would have to make measurements BEFORE THE CHANGE. And you would have to make measurements AFTER THE CHANGE. That's what Ken's group does in this story.



☆1. *They Decide What To Measure and How To Measure It.*

In Ken's school, children have to wait in line a long time to get hot lunch. The students in Ken's class hope to change that. They plan to move the tables around.

They think a new setup will make things better. But they want to be sure. Ken, Jane, and Bob will do an experiment to find out.

They want to measure how long it usually takes kids to get hot lunch. The group decides to record the time when a student gets into the line and then the time he leaves the line with his food. They read "How To" Choose a Sample and decide to time every fifth student in line.

☆ *2. They Make a Test Measurement.*

The next day Ken's group gets a stopwatch. They have already read "How To" Use a Stopwatch. They take turns recording the starting and leaving times for several students as they go through the lunch line. When they look at the data they see that Ken put down minutes, seconds, and fractions of sections. Jane and Bob have put down only minutes and seconds. They discuss how close their measurements have to be, and agree to round off each time to the nearest half-minute. "After all," says Ken, "we'll have to show a change in time a lot bigger than that."

☆ *3. They Keep Everything the Same Except the One Property They Are Testing.*

First, Ken's group measures times BEFORE THEY CHANGE ANYTHING. Then they move the tables.

Second, they measure times AFTER THE CHANGE has been made.

But Ken's group is careful. They make their measurements on the two days in the same way.

- On both days the same hot lunch is served.
- On both days they do the timing the same way.
- On both days they pick their sample of kids the same way.

☆ *4. They Repeat the Measurements Several Times.*

"We should take our measurements again to make sure that we didn't make a mistake," says Ken.

"How can we take the measurements again?" asks Bob. "The line will have moved by the time we're ready to measure again."

"Three people can do the timing and keep separate records," suggests Ken. "That way we'll know if someone made a mistake in timing."

"We'll also find out if something is different that we didn't think about," Jane added.

☆ *5. They Think Carefully About the Data.*

The next day Ken's group looks at the data. "There is a half-minute difference in the first times recorded by the three timers," remarks Ken.

"That seems a lot, but we rounded off. A small difference could make a one-half minute difference on our record," Bob says. "I think our data are O.K."

The others agree. Next they wonder about what to do with their data. They read "How To" Use Key Numbers to Compare Two Sets of Data. They decide to take the median of each set of three timings. Then they make more charts. Parts of the new data charts look like this.

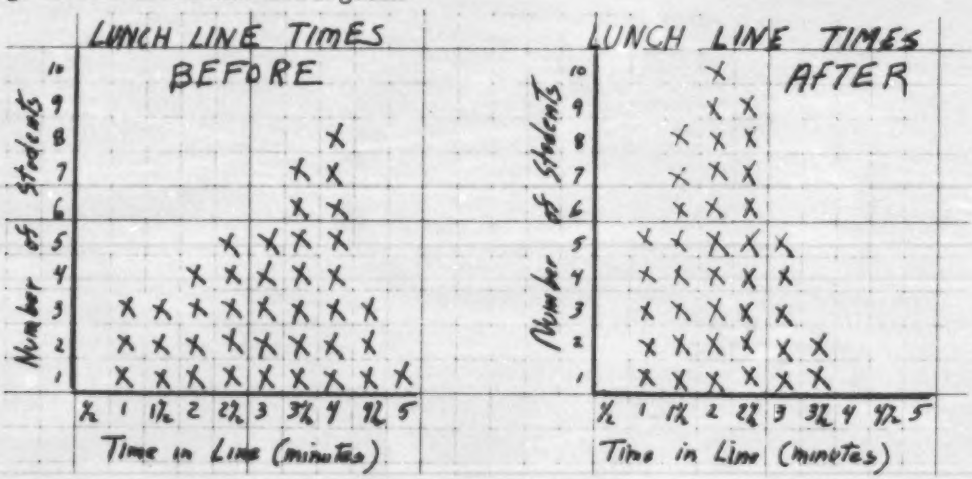
BEFORE

LUNCH LINE TIMES 9/26	
Person	Median Time (min.)
Rosie	1
Jean	1
Roger	1
Sam	2½
Virgil	2½
James	4½
Sally	5

AFTER

LUNCH LINE TIMES 11/5	
Person	Median Time (min.)
Susie	1
Ray	1
Calvin	1
Sonny	1½
Jessie	1½
Andrea	3½
George	3½

Ken's group then decides to make two histograms of their data--a BEFORE histogram and an AFTER histogram.



☆6. *They Decide What the Experiment Tells Them.*

"The graphs show that after we changed the lunchroom, the lunch line moved faster," Ken says. "Our change did make things better."

"Maybe something else made the line move faster," Jane says.

"What else could it be?" Ken asks.

There is no answer. The group can't think of anything else that was different on the two days.

CHANGING ONLY ONE THING AT A TIME

Sometimes you may want to find out about two things--or three things. Suppose you are growing plants for the school fair. You want to find out what type of light makes your plants grow faster. You may also want to find out which type of fertilizer makes them grow faster. You would have to make measurements with different lights and with different fertilizers. But you should change only one thing at a time. So you are really doing two experiments. That's what Henry's group found out in this story.

Henry, Sally, and Anne want to make their marigold plants grow faster. They talk about how they can do it.

"I'll bet they'll grow faster on the window sill than under the fluorescent light," says Anne.

"What about cloudy days?" asks Sally. "On those days the plants won't get any sun on the window sill. They will get light all the time under fluorescent lights."

Henry suggests, "Let's do an experiment. We can put half of our plants on the window sill and leave the other half under the lights. We'll measure their heights now and again in a week. Then we'll know where the plants grow faster."

"Fertilizer will help them grow faster, too," says Anne. "I can bring in some fish emulsion from home."

"I'll bring in some of the fertilizer my mother uses," offers Sally.

"How will we know which fertilizer is better?" asks Anne.

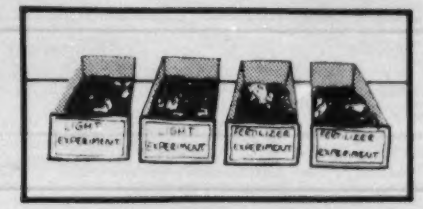
"Let's do the same thing with the fertilizer that we're doing with the lights," Henry suggests. "Use one fertilizer with half of the plants and the other fertilizer with the other half."

"That's right," says Anne. "We can put fish emulsion on the plants going on the window sill and the other fertilizer on the plants under lights."

"Wait a minute!" shouts Sally. "If the plants on the window sill grow faster than the others, how will we know whether the sun or the fish emulsion was the thing that helped?"

"We won't be able to tell if we change two things at a time," says Henry.

"We'll have to divide our plants into four groups and do two experiments," Anne suggests. "We'll use two groups to test the light and two groups to test the fertilizer."

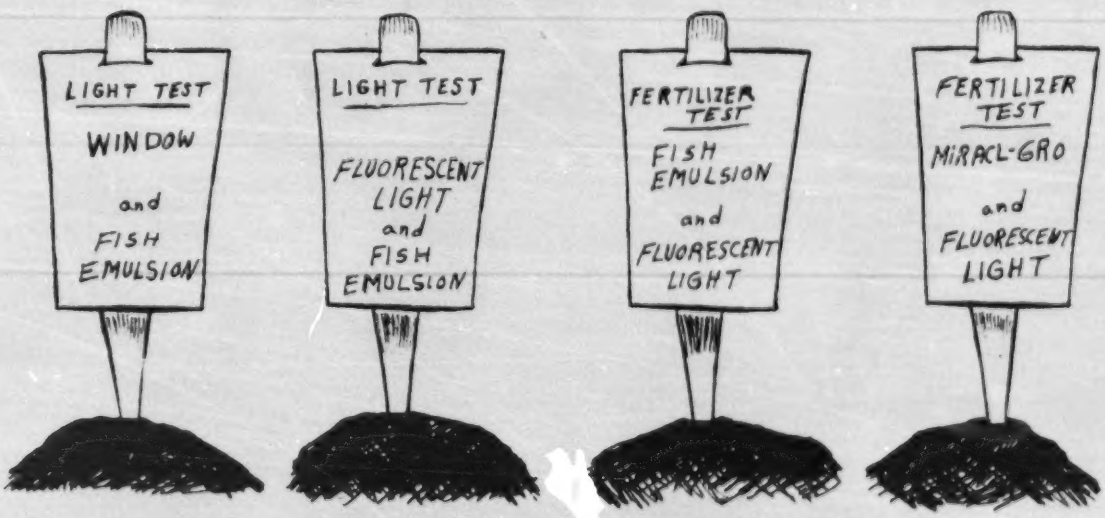


"When we test the light, we'll use the same fertilizer," adds Sally. "And when we test the fertilizer, we'll use the same light."

The group decides to do the fertilizer test under the fluorescent lights. They decide that if they put the two groups of plants at the same distance from the light and under the middle of the light, all plants should get the same light. They also agree to follow the instructions on both fertilizers and be careful to use the same amount of each fertilizer each time.

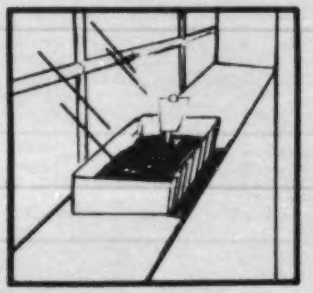
The group also decides to use fish emulsion for the light test. They agree that they'll be careful to shake the bottle and mix exactly the same amount of fish emulsion in the same amount of water for both groups of plants. They decide to use the same soil and the same number of seeds from the same package. They also decide to plant the seeds in each box in the same way.

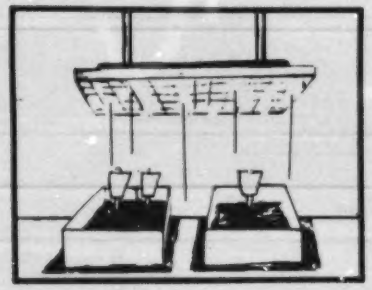
Henry, Anne, and Sally then make up labels for the four groups of plants.



"Look at the labels," remarks Henry. "We have two for the same thing: fluorescent light and fish emulsion."

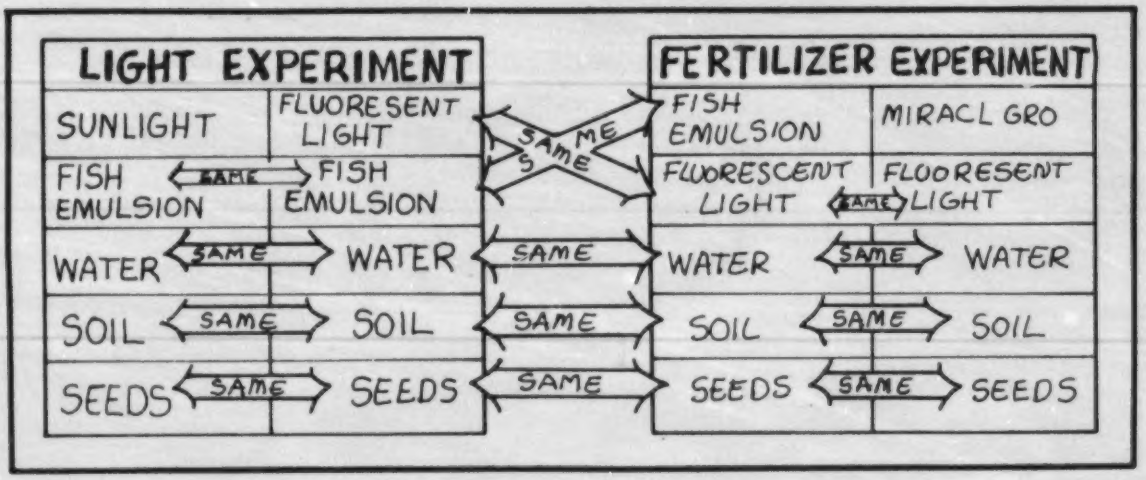
"That's right," Jane agrees. "Then we'll need only three boxes of plants. The plants that are put under fluorescent light and given fish emulsion will give us data for both experiments."





"We'll have to be careful to keep the amounts of fish emulsion and fluorescent light the same for both experiments," Henry says.

The group agrees to use only three boxes of plants. To remind themselves that they are doing two experiments, they decide to use all four labels. They also make a check list for each experiment.



HOW TO DO YOUR EXPERIMENT

So far you have read stories about children doing experiments. How should YOU do YOUR experiment? How can you make sure that you are doing a fair experiment? Before you do your experiment, you should read "How To" Collect Good Data. Here is a checklist you can follow as you plan and do your experiment.

☆1. DECIDE WHAT TO MEASURE AND HOW TO MEASURE IT.

☆2. MAKE A TEST MEASUREMENT IF YOU CAN.

☆3. KEEP EVERYTHING THE SAME EXCEPT THE ONE PROPERTY YOU ARE MEASURING.

Watch out for differences in times, differences in places, differences in ways the measuring is done, and lots of other things.

☆4. REPEAT YOUR MEASUREMENTS SEVERAL TIMES.

Maybe you didn't think of everything that was changing as you did your experiment.

Repeat your experiment and check the results. Are the results different? If so, you can think about what went wrong. If the results are the same, you can be more certain they are right.

Number of Scrubs -- Rick 4/4

Test	Floffy	Squeezy
#1	12	8
#2		
#3		
#4		
#5		

Number of Scrubs -- Joan 4/4

Test	Floffy	Squeezy
#1	14	10
#2	11	11
#3	10	9
#4	11	8
#5		

Number of Scrubs -- Lucy 4/4

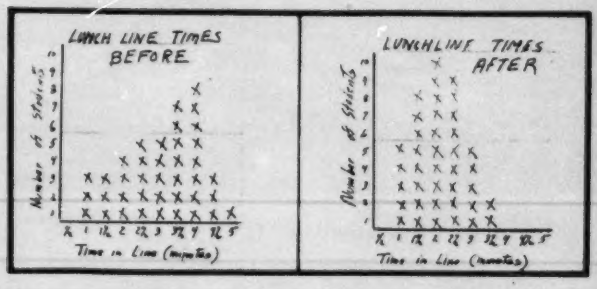
Test	Floffy	Squeezy
#1	18	12
#2	16	14
#3	14	10
#4	16	12
#5	12	9

☆5. THINK CAREFULLY ABOUT YOUR DATA.

Look at your numbers. Do some of your numbers look strange? Do some of the numbers look as if they don't fit with the rest of your data? If so, think about what might have happened.

Now check your numbers to see if they give you the information you need. If not, you may have to use your numbers to find other numbers. Or you may have to make a graph of your data. You can read "How To" Use Key Numbers to Compare Two Sets of Data or "How To" Use Graphs to Compare Two Sets of Data to find out more about these things.

☆6. DECIDE WHAT YOUR EXPERIMENT TELLS YOU.



Look at your numbers or your graphs. Are the results different enough to say that one thing was better than another? Are they different enough to say that a change has made things better? To draw conclusions, you'll have to think hard about whether the difference is important or not.

REMEMBER: YOU SHOULD CHANGE ONLY ONE THING AT A TIME WHEN YOU DO AN EXPERIMENT.

Make sure you are testing only one thing. If you want to find out about several things, do a separate experiment for each.

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"HOW TO"

MAKE AN OPINION SURVEY

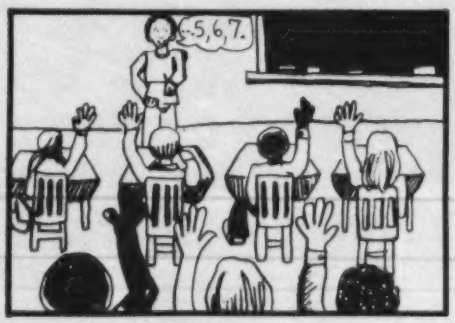
DO YOU WANT TO FIND OUT HOW PEOPLE FEEL ABOUT SOMETHING?

Maybe you want to know what games or drink flavors kids like. Maybe you want to know what problems people have in the lunchroom or getting around school.

YOU CAN MAKE AN OPINION SURVEY TO FIND OUT.

When you ask a lot of people the same questions, you are conducting an opinion survey. There is more than one way to conduct a survey:

- You can ask one person at a time.
- You can ask a lot of people together.
- You can write down your questions and give them to people.



However you do it, do it carefully. Lots of things can go wrong when you make a survey. If something goes wrong, you may have to conduct your survey again. That could take a lot of time. That's why you should plan your survey carefully.

This booklet will help you make an opinion survey.

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MAKING YOUR OWN SURVEY	13

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NINE STEPS FOR MAKING A SURVEY

★ 1. DECIDE EXACTLY WHAT THINGS YOU WANT TO FIND OUT.
★ 2. WRITE DOWN THE SURVEY QUESTIONS.
★ 3. TEST THE SURVEY TO SEE IF IT WORKS.
★ 4. FIX THE MISTAKES IN THE SURVEY.
★ 5. DECIDE WHOM TO SURVEY.
★ 6. CONDUCT THE SURVEY.
★ 7. TALLY THE RESULTS.
★ 8. LOOK CAREFULLY AT THE DATA.
★ 9. DECIDE WHAT THE SURVEY TELLS YOU.

Do you want to see how students follow these steps?
Read this story about Lionel and his two friends.

A CLASSROOM SURVEY: GAMES PEOPLE LIKE

Lionel's class is making games. The children are going to play the games during their free time. Joan, Jerry, and Lionel want to make a game that everyone will want to play. Lionel thinks that a survey will help them make a good game.

★ *1. They Decide Exactly What Things They Want To Find Out.*

"Why do you want to make a survey?" Joan asks Lionel.

"To find out what games we like," he answers.

"You mean like Monopoly or checkers or a bean bag toss?" Jerry asks.

"Yes," Lionel says.

But Joan is confused. "What good will that do?" she says.

"It will tell us what kinds of games kids like," Lionel says.

"Oh, you want to find what KINDS of games kids like," Joan says. "You mean board games or throwing games or card games or things like that?"

"Yes," Lionel says.

"O.K.," Joan says. "Then we'll do a survey to find out what KINDS of games kids like the most."

★ *2. They Write Down the Survey Questions.*

Lionel, Joan, and Jerry are sitting around a table. Jerry has the pencil and paper. "What should I write?" he asks.

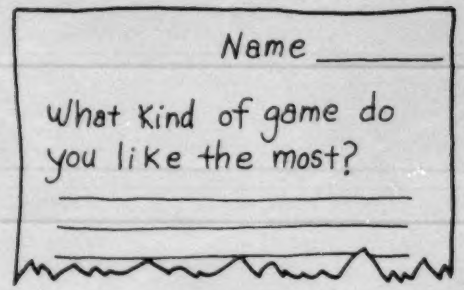
"Try writing 'What games do you like?'" Lionel says.

"That's not what we want to find out," Joan says. "We want to find out about KINDS of games."

"O.K.," Lionel says. "Write 'What KIND of game do you like the most?'"

"Yes, that's good," says Jerry. "Anything else?"

"Just put a line at the top for the name," Lionel says.



★ *3. They Test the Survey To See if It Works.*

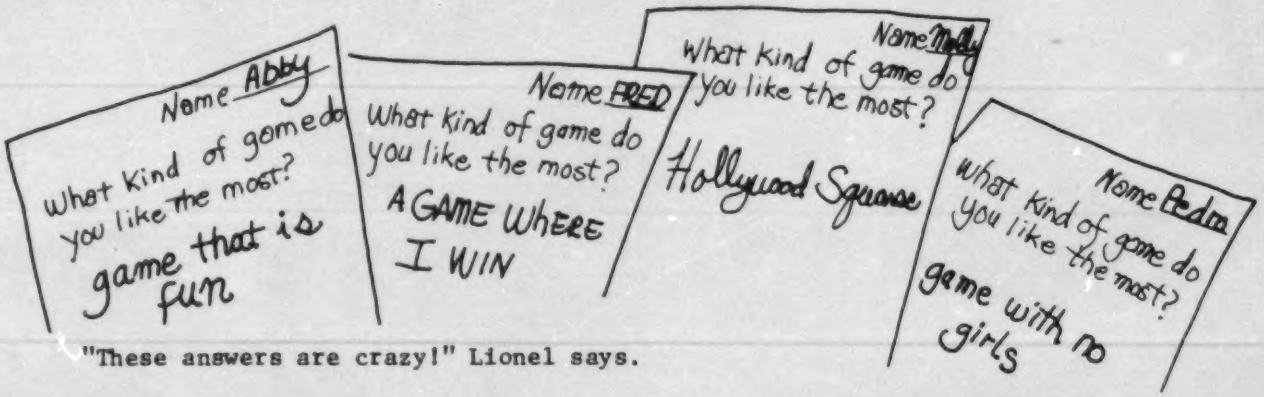
"Let's try out our survey," Jerry says, holding up the paper.

"What for?" Lionel asks.

"To make sure that people can understand it," Jerry answers.

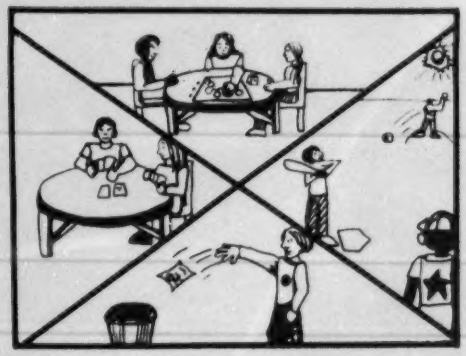
"And," Joan adds, "to make sure that we'll find out what we want to know."

"O.K. Let's try it out on Pedro's group," Lionel says. "There are five kids in that group." They make five copies of the survey. They give one copy to each person in Pedro's group. Each person fills out the survey. Lionel's group collects the sheets and looks at the answers.


Name Abby
What kind of game do you like the most?
game that is fun
Name FRED
What kind of game do you like the most?
A GAME WHERE I WIN
Name Molly
What kind of game do you like the most?
Hollywood Squares
Name Pedro
What kind of game do you like the most?
game with no girls

"These answers are crazy!" Lionel says.

"Yes," Joan says. "We wanted to find out whether they like board games or card games or things like that. These answers don't tell us what we need to know."



★ 4. *They Fix the Mistakes in the Survey.*

"I guess our survey isn't so good," Lionel says. "It looks like nobody knew what we meant when we wrote KIND of game."

"What did we mean, anyway?" Jerry asks.

"We meant board games or card games or word games," Lionel says.

"Or throwing games, like a bean bag toss," Joan adds.

"Well," Jerry says, "let's write down the kinds of games we mean. Then everyone can just mark the one they like most."

"But I like board games and card games about the same," says Lionel.

"Let's give everyone one or two choices," says Joan.

Lionel, Joan, and Jerry write down their new survey. It looks like this.

Name _____

What kind of games do you like to play the most? Circle one or two.

BOARD GAMES
CARD GAMES
WORD GAMES
THROWING GAMES

★ 5. *They Decide Whom To Survey.*

"Now we have our survey," Lionel says. "Whom should we give it to?"

"We're making games for people in our class," Jerry says. "So we should survey everyone in our class."

"O.K.," says Joan. "We need to make 22 copies of the survey, one for each kid."

★ 6. *They Conduct the Survey.*

"I've got the copies of the survey," Joan says, as she holds up the stack of papers. "When should we give it out?"

"Mrs. Gonzalez said we can do it this afternoon," Lionel says.

"Where?" Joan asks.

"In the classroom, of course," Lionel says.

"How should we do it?" says Joan.

"I'll tell the class about the survey," Jerry says. "I'll tell everyone why we need the information. And I'll explain how they should fill it out."

"Then I'll give out the surveys," Joan says. "When everyone is done, we can all help collect them."

That afternoon, their class fills out the surveys.

★ *7. They Tally the Results.*

Lionel, Jerry, and Joan read the booklet "How To" Record Data. Then they draw a tally chart like this.

GAMES PEOPLE LIKE 11/4	
KIND OF GAMES	HOW MANY CHOSE IT
BOARD GAMES	
CARD GAMES	
WORD GAMES	
THROWING GAMES	

Joan has all the surveys. She looks at them one at a time. She reads aloud what each child put down. "One for CARD GAMES," she says. Jerry makes a mark in the right place. They go through all 22 copies. Their chart looks like this.

GAMES PEOPLE LIKE 11/4	
KIND OF GAMES	HOW MANY CHOSE IT
BOARD GAMES	𝍸 𝍸 𝍸 (15)
CARD GAMES	𝍸 1111 (9)
WORD GAMES	𝍸 11 (7)
THROWING GAMES	𝍸 𝍸 (10)

★ *8. They Look Carefully at the Data.*

Lionel, Joan, and Jerry look at the tally chart. Jerry counts the total number of marks.

"There are 41 marks all together," he says.

"We gave out 22 surveys," says Joan. "Most kids did vote for 2, but a few voted just for 1."

"Yes," Lionel says. "Our results seem to make sense. There's nothing strange."

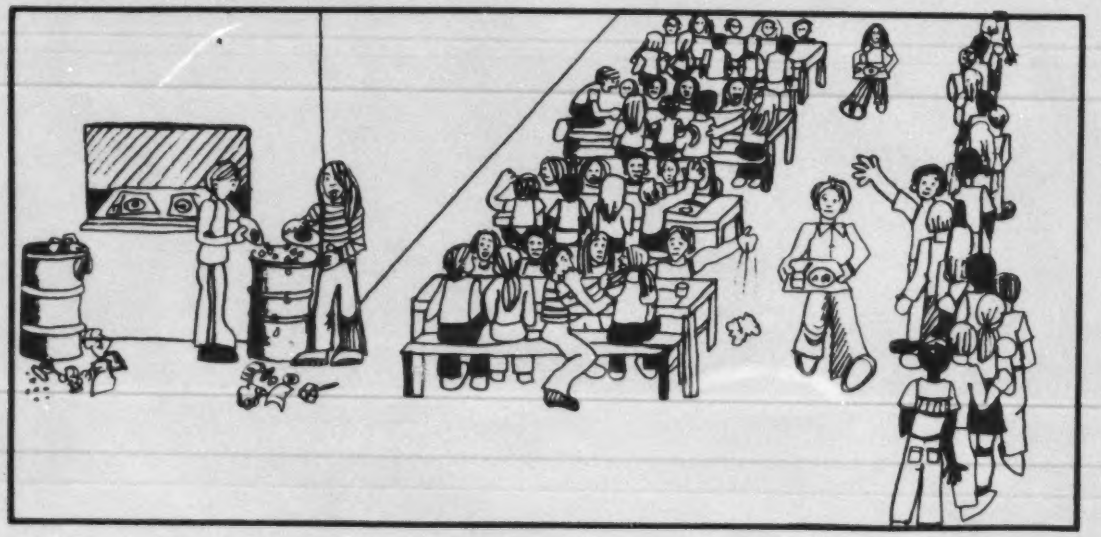
★ *9. They Decide What the Survey Tells Them.*

Jerry agrees that the data are all right. Then he adds, "Well, it looks like board games are the favorite kind of game in our class."

A SCHOOL SURVEY: WHAT'S EATING YOU AT LUNCH

In the last story, Lionel and his friends needed to survey only their class. You may need to survey other classes. That's what Lena and her group do in this story. But they follow the nine steps, too.

Lena's class wants to make the lunchroom better. There are a lot of things about the lunchroom that the students don't like. Some kids think the lunchroom is too noisy. Some think it's too ugly and messy. Some think it's too crowded. Some kids think the food is bad. Some think the lunch line is too long and moves too slowly. There are other problems, too.



The class wants to fix the biggest problem first. But how will they know what the biggest problem is? Lena's group thinks a survey will tell them.

★ *1. They Decide Exactly What Things They Want To Find Out.*

"What do we want to find out from our survey?" Lena asks her friends Gary and Nancy.

"How kids feel about the lunchroom," Gary says.

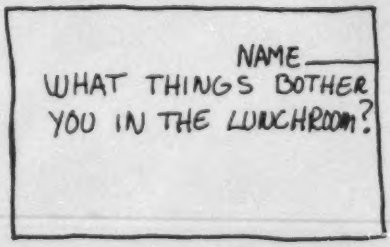
"More than that," Nancy adds. "We want to know what the biggest problem in the lunchroom is."

"Yes," says Gary. "We want to know what thing about the lunchroom bothers the most kids."

★ *2. They Write Down the Survey Questions.*

"Let's ask 'What things bother you in the lunchroom?'" Lena says.

"O.K.," the others agree. Gary writes it down.



★ *3. They Test the Survey To See if it Works.*

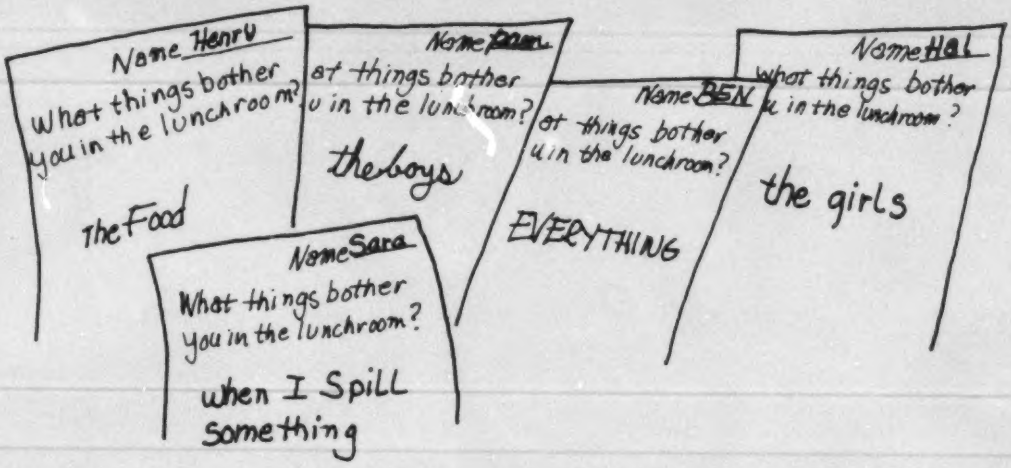
"Let's try out our survey," Lena says.

"Yes," Nancy says. "That way we'll know if other kids understand it."

"And we'll see if we asked the right question," Gary adds.

"We can try it out on Henry's group," Lena says.

They make five copies of the survey. They give one copy to each member of Henry's group. A few minutes later, they collect the surveys. They look at the results. But they don't like them.



"These answers are no good," they say. "They don't tell us what we want to know."

★ *4. They Fix the Mistakes in the Survey.*

"I guess nobody understood our survey," Lena says. "I wonder how we can make it clear."

Gary has an idea. "We can ask one question for each thing," he says. "Then kids can just write yes or no."

"You had better show us what you mean," Nancy says. Gary writes the survey. Then he shows it to Lena and Nancy.

LUNCHROOM SURVEY Name _____

Are you bothered because

① the lunchroom is too noisy? yes ___ no ___

② it takes too long to go through the line? yes ___ no ___

③ the lunchroom is ugly? yes ___ no ___

④ the food does not taste good? yes ___ no ___

⑤ the tables are too crowded? yes ___ no ___

"That looks good," Nancy says. "Let's use it."

But Lena doesn't agree. "It's O.K.," she says, "but what happens if a problem bothers someone just a little? Then he may not want to write YES and he may not want to write NO."

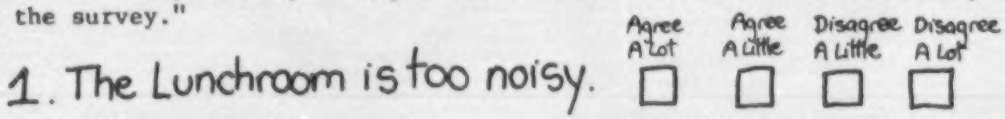
"But YES and NO are the only choices," Gary says.

"That's just the trouble," Lena answers. "Maybe we should have more than two choices for each problem."

"I know!" shouts Nancy. "We can have four choices for each problem."

"How? Gary and Lena ask.

"I'll show you," says Nancy. "Here is how we can write the first problem on the survey."



"The person checks the box that describes how he feels about the problem," Nancy explains. "Let's say the person agrees a lot that the lunchroom is too noisy."

"Then he puts a check in the first box," says Gary, not waiting for Nancy to finish.

"Right," says Nancy.

"And if he agrees only a little, then he puts a check in the second box," Lena says.

"Right again," says Nancy. "And if he disagrees a little, he checks the third box. And if he disagrees a lot he checks the fourth box."

"So there are four choices all together," says Gary, "two kinds of YES answers and two kinds of NO answers."

"Yes," Lena says. "There's a big YES, a little YES, a little NO, and a big NO."

"And," Nancy adds, "we can give the same choices for each problem on the survey."

They all like the idea. So they work at it. They end up with this survey.

LUNCHROOM SURVEY NAME _____

Next to each statement, please put an X in the box that best tells how you feel.

PROBLEM	Agree A Lot	Agree A Little	Disagree A Little	Disagree A Lot
1. The lunchroom is too noisy.				
2. It takes too long to go through the line.				
3. The lunchroom is ugly.				
4. The food does not taste good.				
5. The tables are too crowded.				

"That looks good," they all agree. Then they test the survey on some friends in their class. Their friends have no trouble filling out the survey.

★ 5. *They Decide Whom They Will Survey.*

"Should we survey everyone in the school?" Lena asks.

"No," Nancy says, "because some people don't eat in the lunchroom."

"You're right," Lena says. "The kindergartners aren't here for lunch. We shouldn't survey them."

"And teachers eat in the teachers' room," Gary says. "So we shouldn't survey them either."

"We should survey everyone else," says Lena.

"That's a lot of people," Nancy says.

"We can't survey all those people," Gary adds. "It will take too long. And it will take too long to tally all the results."

They ask their teacher how many people they will have to survey. He shows them the pamphlet, "How To" Choose a Sample. They read it. Then they decide how they will choose kids to survey.

★ 6. *They Conduct the Survey.*

They make one copy of the survey for each person they will question. They decide WHEN they will give out the survey. They decide WHERE they will give out the survey. They decide HOW they will give out the survey. (They talk about what they will say and what they will do.) Then they conduct the survey.

★ 7. *They Tally the Results.*

Lena, Gary, and Nancy make a tally chart. Then they read each survey that they collected. They fill out the tally chart--one survey at a time. Finally, the chart looks like this.

LUNCHROOM SURVEY

PROBLEM	Agree A Lot	Agree A Little	Disagree A Little	Disagree A Lot
1. The lunchroom is too noisy.	43	18	19	40
2. It takes too long to go through the line.	22	39	38	21
3. The lunchroom is ugly.	11	22	40	47
4. The food does not taste good.	49	43	20	8
The tables are too crowded.	51	35	23	11

★ 8. *They Look Carefully at their Data.*

"I'm sure glad all that tallying is over," Nancy says. "Now, which problem is the most important?"

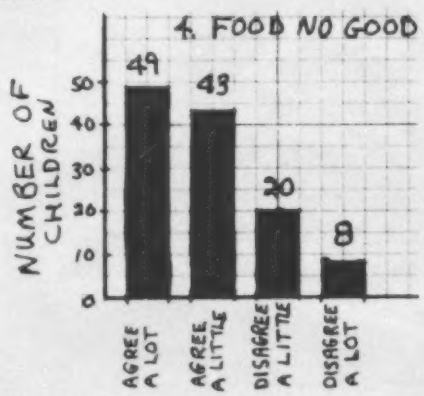
"I don't know," says Lena. "There are so many numbers."

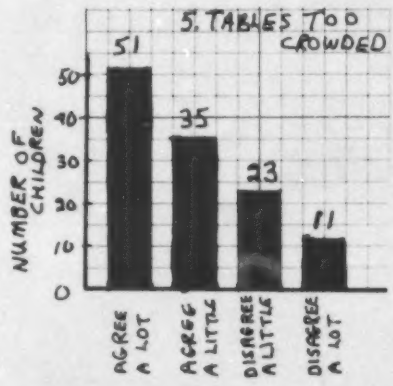
"I wish we had a better way to look at our results," Nancy says.

"We can make bar graphs," says Gary. "That will make it easier to understand our data." They read the pamphlet "How To" Make a Bar Graph and then make bar graphs--one for each problem on the survey.

★ 9. *They Decide What their Survey Tells Them.*

The children study the graphs for a while. Then Lena says, "It looks like two big problems are that the food is no good and that the tables are too crowded.

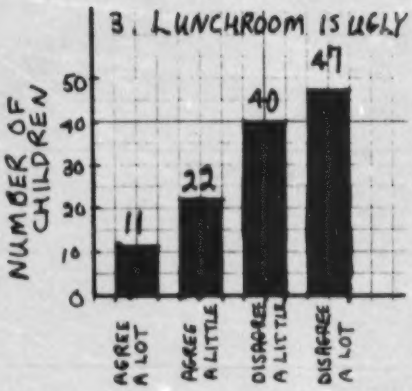




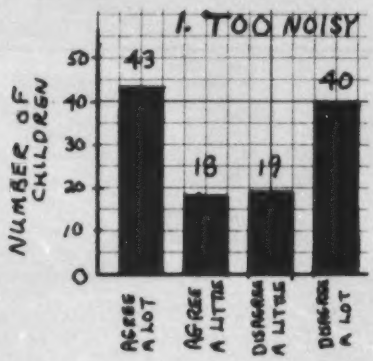
"Yes," Nancy agrees. "I can tell from these graphs that most kids agreed a lot or agreed a little. The bars are tall on the AGREE sides of the graphs and short on the DISAGREE sides."

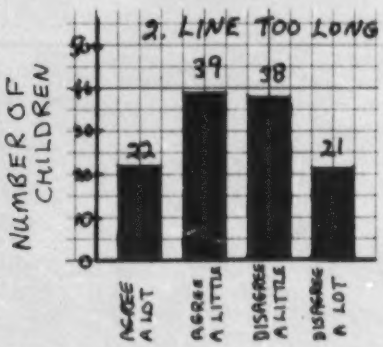
"I can tell that an ugly lunchroom is a small problem," Lena says. "The bars are tallest on the DISAGREE side of the graph."

"You're right," says Gary. "Very few kids agreed that the lunchroom is ugly. Most disagreed. I guess that's not really a problem."



"Well," says Nancy, "we know that two problems are big, and we know that one is small. But what about the other two problems--the noise and the lunch line?" Pointing to the graphs for those problems, she notes, "There are tall bars on both the AGREE sides and the DISAGREE sides."





"Look at the noise graph," says Gary. The tallest bars are for AGREE A LOT and DISAGREE A LOT. Most kids had strong feelings about noise."

"Maybe we need a quiet corner for eating," says Lena.

"Maybe," says Gary. "Anyway, kids sure felt strongly about noise."

"Yes," says Nancy, "but kids did not feel so strongly about the lunch line problem. The tallest bars are for AGREE A LITTLE and DISAGREE A LITTLE."

"But how do we tell which is the biggest problem?" says Gary. "Is it bad food or crowded tables? The graphs are almost the same."

"Let's ask Mr. Parker."

The teacher tells them a way to get a score for each of those two problems. He suggests giving 4 points to each vote for AGREE A LOT, 3 points to each vote for AGREE A LITTLE, 2 points for DISAGREE A LITTLE, and 1 point for DISAGREE A LOT. "Then you can compare the two scores," he says.

The students then make a chart to record their results. "There are 49 votes for AGREE A LOT for the problem 'The food is no good'," says Nancy. "That's 49 times 4, or 196 points."

"There are 43 votes for AGREE A LITTLE for that problem," says Gary. "That's 43 times 3, or 129 points."

NUMBER OF VOTES	×	NUMBER OF POINTS	=	TOTAL POINTS
49	×	4	=	196
43	×	3	=	129

They quickly finish filling in the chart.

PROBLEM	AGREE A LOT 4 Points	AGREE A LITTLE 3 Points	DISAGREE A LITTLE 2 Points	DISAGREE A LOT 1 Point	TOTAL
4. The food does not taste good.	49×4=(196)	43×3=(129)	20×2=(40)	8×1=(8)	373
5. The tables are too crowded.	51×4=(204)	35×3=(105)	23×2=(46)	11×1=(11)	366

"It's still close," says Lena. "'Food does not taste good' has 373 points and 'Tables are too crowded' has 366. That's a difference of 7 points. Let's work on the food problem first."

MAKING YOUR OWN SURVEY

You have read stories about students making surveys.

How should YOU make YOUR survey?

You can follow the same nine steps that the children in the stories followed.

★ 1. DECIDE EXACTLY WHAT THINGS YOU WANT TO FIND OUT.

★ 2. WRITE YOUR SURVEY.

- Make sure your questions are clear.
- Make sure your questions ask what you want them to ask.

★ 3. TEST YOUR SURVEY.

- Try out your survey on a few people. (You can use some students in your class.)
- Look at the way the people filled out your survey. Did people fill out the survey the way you wanted them to? If not, you should figure out why.

★ 4. FIX THE MISTAKES IN YOUR SURVEY.

- Did your test show that something is wrong with your survey?
- If it did, then fix your survey to make it better.

★ 5. DECIDE WHOM YOU WILL SURVEY.

- Do you need to survey the people in your class?
- Do you need to survey all the students in your grade?
- Do you need to survey all the students in the school?
- Do you need to survey other people, too? Teachers? Parents?

If you need to survey a lot of people, you can save time. You can survey just some of those people. Read "How To" Choose a Sample. Then choose a sample. Survey the people you choose.

★ 6. CONDUCT YOUR SURVEY.

- Decide WHEN you will do it.
- Decide WHERE you will do it.
- Decide HOW you will do it. (What will you say when you give the survey?)

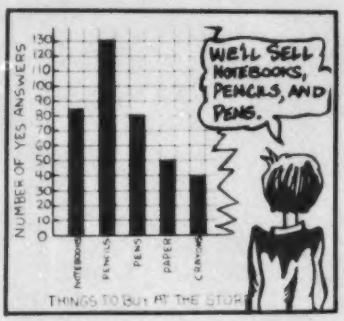
Then conduct your survey as you've planned.

★ 7. TALLY YOUR RESTULTS.

- Make a tally chart. You can read "How To" Record Data to find out how to make a tally chart.
- Tally the results of your survey on your tally chart.

★ 8. LOOK CAREFULLY AT YOUR DATA.

- Do your results make sense? If not, try to figure out what went wrong.
- Do you need to draw graphs to help you understand your data? If so, then do it.



★ 9. DECIDE WHAT THE SURVEY TELLS YOU.

- Can you find out what you wanted to know from the numbers?
- If not, can you find out what you wanted to know from your graphs?
- If the graphs don't give you the answer, maybe you need to find a total score for the survey answers by giving them 4 points, 3 points, 2 points, and 1 point.

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"HOW TO"

CHOOSE A SAMPLE

DO YOU WANT TO FIND OUT SOMETHING FROM A LOT OF PEOPLE?

You may have questions like these:

- What things will kids buy from our school store?
- How long do kids have to wait in line for lunch?
- How fast are cars driving on the street in front of the school?

If takes a lot of time to--

- ask everyone in the school
- measure the time everyone has to wait in line for lunch
- measure the speed of every car that passes the school

YOU CAN SAVE TIME BY TAKING A SAMPLE SURVEY

A sample is a part of a whole group. When you want to find out something about the whole group of people or things but you ask or measure only some of them, you are taking a sample survey.

WHY YOU SHOULD CHOOSE YOUR SAMPLE CAREFULLY

There are lots of ways of choosing a sample. But lots of things can go wrong. Your sample might not give you the right results. Results from the whole group might be different. If you want to use your results from your sample to decide something, you want to choose your sample carefully. This booklet will help you learn how to choose a sample that will give you good results. Tables in the back of the booklet will help you decide how big your sample should be. They will also help you use one of the ways to choose a sample.

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SIX STEPS TO FOLLOW IN CHOOSING A SAMPLE

☆1. DECIDE WHAT GROUP OR GROUPS YOU ARE INTERESTED IN.
☆2. DECIDE WHETHER YOU WANT TO COMPARE TWO OR MORE GROUPS.
☆3. DECIDE HOW BIG THE SAMPLE SHOULD BE BY USING THE TABLES.
☆4. PICK A METHOD FOR CHOOSING YOUR SAMPLE.
☆5. CHOOSE THE SAMPLE AND DO YOUR SURVEY.
☆6. THINK CAREFULLY ABOUT THE RESULTS.

Do you want to see how students follow these steps? Read this story about George and his friends.

CHOOSING A SAMPLE FOR A SCHOOL SURVEY: BUY IT AT YOUR SCHOOL STORE

George's class is planning to open a school store. They have only a small space for the store. They want to sell only the things that students in the school would buy. George, Dan, and Carolyn have the job of finding this out. Dan thinks that a survey will help them find out what students will buy. The group agrees but thinks that it is too much work to ask everyone in the school. They finally decide to take a sample survey.

☆1. *They Decide What Group or Groups They Are Interested In.*

"Whom should we give the survey to?" asks George.

"Some of those who might buy something in the store," Dan answers. "That's all the students and the teachers."

"What about the kindergarten children?" asks Carolyn. "They are in school only a half day and usually don't have any money."

"That's right," says George. "Only first- through eighth-grade students and teachers are likely to buy things from our store. We'll pick our sample from them"

☆2. *They Decide Whether They Want To Compare Two or More Groups.*

"Students in the upper grades might like to buy different things from those which the students in the lower grades might buy," says Carolyn. "Maybe we'll want to compare what those two groups want to buy at the store."

"You're right," says Dan. "But we can list all sorts of things on our survey. Then if we choose our sample right, we'll get answers from students at all grade levels."

"O.K.," responds Carolyn. "We won't bother to compare the results from the big kids and the little kids. We'll pick our sample from everyone in the school."

☆3. *They Decide How Big the Sample Should Be By Using the Tables.*

"How big should our sample be?" asks George.

"Let's find out how many first through eighth graders we have in the school," says Dan.

"Don't forget about the teachers," Carolyn reminds him.

The group finds our that there are 420 students and 30 adults in the school, counting secretaries and aides.

"What do we do next?" asks George. "We still haven't found out how big our sample should be."

The group asks the teacher. He tells them there are tables in the "How To" booklet that will help them. The group studies the tables.

"We can use Table I," says Dan. "It tells how big the sample should be when you are choosing a sample from one group of people."

"According to Table I there should be 40 people in a sample when the group is 400 or more," says George.

"Some students in our sample may be absent the day we do our survey," says Carolyn. "Let's add 10 to the sample to make it 50."

☆4. *They Pick a Method for Choosing the Sample.*

"We can get a list from the office of all the students' and adults' names," says George.

"What do we do then?" asks Carolyn.

"We need a sample of 50 names from a total list of about 450 names," says George. "We can put all the names on slips of paper, put the slips in a bowl, and pick 50 from the bowl."

"That's a lot of slips of paper," says Carolyn. "It would take too much time. And it would be hard to be sure that we mixed up the slips well."

"Why don't we choose every 9th name on the list?" suggests Dan. "That will give us a sample of about 50."

"O.K.," says George. "Do we start counting from the first name on the first-grade list?"

"We have to make sure that everyone has the same chance of being chosen," says Dan. "Why don't we ask our teacher to pick a number from 1 to 9? Then we'll start counting at that number."

5. *They Choose the Sample and Do the Survey.*

The group follows their plan. The teacher chooses the number 3 when asked to pick a number from 1 to 9. Starting with the 3rd name on the first grade list they pick every 9th name on the lists of students and teachers. They are careful to carry over unused numbers from the first grade list to the second grade list and so on. They do the list of teachers, secretaries and aides last. When they conduct the sample survey, they find that 5 students out of the 47 chosen students were absent; all of the 3 teachers were present.

GRADE 1

Agro, Jessica	Larkin, Beth
Andrews, Jason	Longwood, Fred
Ball, Joan	McInerny, Eric
Brady, Laura	Marshall, George
Cooper, Eloise	Peacock, Frances
Craft, Helen	Petraglia, Joseph
Dunn, Robert	Randolph, Michael
Finstein, Amy	Schneider, Greg
Grant, Alan	Stanton, Jane
Houlihan, Betsy	Stroud, Peter
Howe, Abigail	Thornton, Henry
Jackson, Randall	Walsh, Kerry
Lang, Sarah	Ziff, David

6. *They Think Carefully about the Results.*

"We have survey answers from 45 people," says George. "That should be a big enough sample."

"The way we did it everyone had an equal chance of being picked," remarks Carolyn. "The results ought to be O.K."

"If we want to be sure, we can do it again," says Dan.

"The next time, we can start counting at a different number," suggests Carolyn. "We'll ask another teacher to pick a number."

The group does the survey a second time. This time there are 5 students and 1 teacher absent. They have only 44 questionnaires, but the results are about the same as the first survey. Pencils and pens were the items most needed for the school store. Paper and glue were the least needed.

SURVEY RESULTS OCT. 10

ITEM	VOTES	TOTAL
Notebooks	𝍸 𝍸 I	11
Pencils	𝍸 𝍸 𝍸 𝍸 II	27
Pens	𝍸 𝍸 𝍸 𝍸	30
Paper	𝍸	5
Crayons	𝍸 𝍸 II	12
Glue	𝍸 III	8

SURVEY RESULTS OCT. 17

ITEM	VOTES	TOTAL
Notebooks	𝍸 𝍸 𝍸 III	18
Pencils	𝍸 𝍸 𝍸 𝍸 I	26
Pens	𝍸 𝍸 𝍸 III	23
Paper	III	3
Crayons	𝍸 𝍸 II	12
Glue	𝍸 𝍸	10

CHOOSING A SAMPLE FOR A SCHOOL SURVEY: WE WANT BUSES

George and his group used one method for choosing a sample for a survey for the whole school. Sally, Bob, and Lucy use another method in this story.

Sally's school is a large school in a town that is growing fast. Some students live quite a distance from the school. As some of the streets are still narrow country roads, parents won't let children ride bikes to school. The school board doesn't want to use buses. They say that it shouldn't take too long for students to walk to school, even the ones who live far away. Many students in Sally's class are tardy so often that it's hard to have field trips that start right away. Also, many students are tired when they get to school. Sally's class wants to prove that buses are needed. They decide to find out how long it takes students to walk to school. Sally, Bob, and Lucy want to conduct a survey. Because it is such a large school, they decide to choose a sample and take a sample survey.

1. They Decide What Group or Groups They Are Interested In.

"Will we include teachers in our sample?" asks Sally when the group meets to plan the survey.

"Teachers all drive to school," says Lucy. "They're the lucky ones."

"Then we should choose our sample from all the students in the school," says Sally.

2. They Decide Whether They Want To Compare Two or More Groups.

"It takes little kids a lot longer to walk to school than bigger kids," says Bob.

"That's right," agrres Lucy. "We'll want to know how long it takes the primary kids to get to school and how long it takes older kids."

"Then we'll really have two samples," says Bob. "We'll pick one sample from all of the students in the primary grades, and the other sample from the students in the intermediate grades."

3. They Decide How Big the Sample Should Be By Using the Tables.

"We need to know how many primary students and how many intermediate students there are in the school," says Sally. "Let's ask the principal." The group finds out that there are about 500 students in the primary grades and about 700 students in the intermediate grades.

"Now we can use the tables in the "How To" booklet to find out how big our sample should be," says Bob. "We can use Table I. We want to find out how long it takes each group to walk to school. But we're not comparing the two groups."

"We'll need 40 students for each sample," says Lucy as she reads Table I.

"Let's add 10 to each sample in case some students are absent," suggests Sally.

4. They Pick a Method for Choosing the Sample.

"When we choose the sample, we'll have to keep the younger kids separate from the older kids," says Sally.

"We can get class lists from the office and separate them into two parts," Bob suggests. They do this and wonder what they should do next.

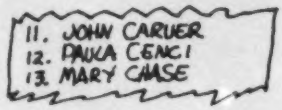
The teacher comes by the group and says that there is a random number table in the "How To" booklet that they can use. She explains that first they give a number to each name on the lists. Then they use the table to choose numbers for each sample.

TABLE OF RANDOM NUMBERS

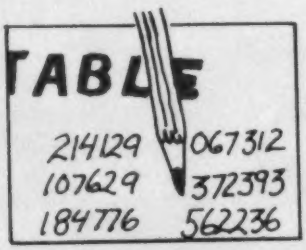
188970	014150	214129	067312
971114	036525	107629	372393
199278	426340	184776	562236
737509	824449	900504	921737
643971	169205	327821	622024
533283	745225	670451	525624

5. They Choose the Sample and Do the Survey.

The group first numbers the names on the primary-grade lists from 1 to 512. Each name has a different number.

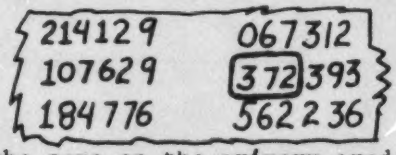


Then Bob drops a pencil point down on the random number table. He finds the digit on the table that is closest to the first pencil mark. It is the mark that is the darkest.

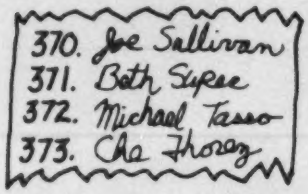


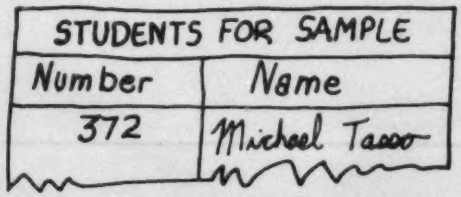
"The darkest mark is closer to the 3 than any other number," says Bob. "Three is the first digit for our first number."

"The numbers on our primary grade lists go up to 512," says Lucy. "We'll have to take 3 digits at a time from the table. Our first number is 372."



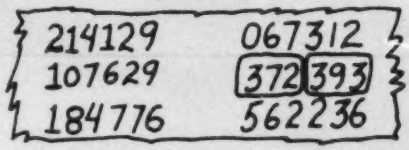
Sally finds the name on the primary grade lists that is numbered 372. She writes that name on a list for the sample.





"What do we do next?" asks Bob.

"We can't skip any digits in the table," says Lucy. "So our next number is the next three digits. It's 393."



"What do we do if we get a number over 512?" asks Bob. "We don't have names numbered over 512."

"Well just go on to the next 3 digits," says Lucy. "There are lots of digits in the table."

The group continues to take 3 digits at a time from the table until they have 40 names plus 10 extra names. Sometimes they get a number starting with a zero, like 024. They write down the student's name that is numbered 24. Sometimes the number starts with two zeros, like 008. They write down the student's name that is numbered 8.

The next day the group uses the same method to get 50 names of older students. The group then conducts their sample surveys. They are careful to do the surveys only on nice days because some students get rides to school on rainy days.

6. *They Think Carefully about the Results.*

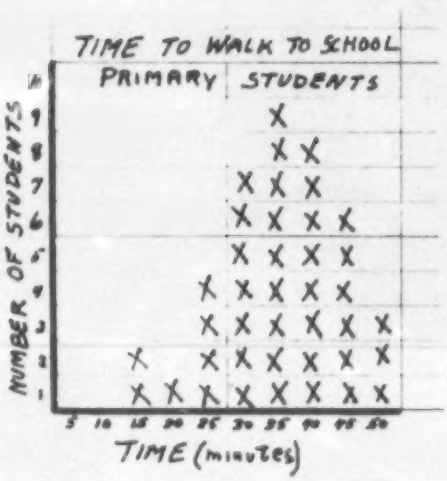
"We have answers from 40 primary students and 40 older students," says Sally.

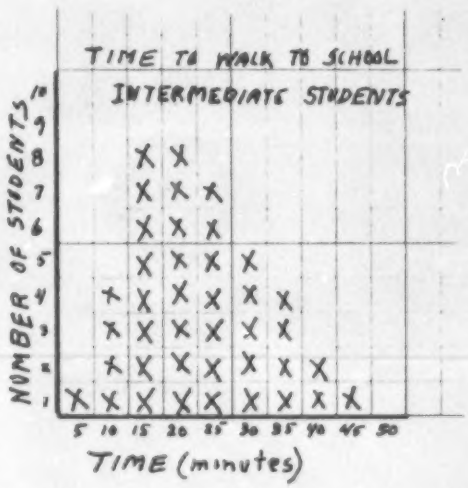
"Lots of the primary students take more than 30 minutes to get to school," says Lucy as she studies the answers.

"Not too many older students take more than 25 minutes to get to school," Bob says.

"I can't think of any way that our surveys could be wrong," Lucy states. Maybe there is a reason for the times to be different. Let's ask the principal whether families with little kids live farther from the school."

The group finds out that families with little kids live all over the school district. They decide that little kids take longer to walk to school. The *principal asks the group to tell the school board about their surveys.* The group agrees to do it and prepares a presentation using the results of their surveys. They read "How To" Use Graphs to Compare Two Sets of Data, and then make two histograms to show to the school board.

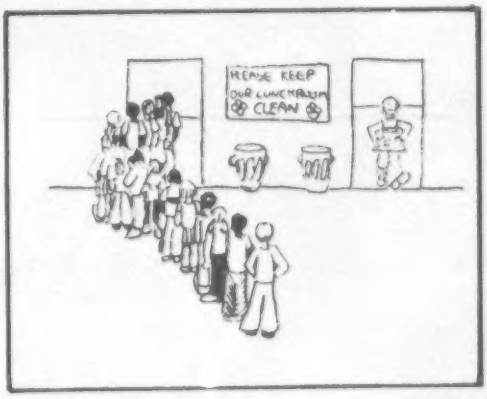




CHOOSING A SAMPLE OF PEOPLE IN A LINE: NO TIME TO EAT

In the stories BUY IT AT YOUR SCHOOL STORE *and* WE WANT BUSES, *the students could tell ahead of time what group they wanted to survey. In this story, the students are working on a problem where it is hard to tell ahead of time exactly whom they need to survey. Because they can't choose their sample from lists, they use another method.*

In Jane's school the students complain about having to wait in the lunch line so long that they don't have much time to eat their lunch. Jane's class thinks that a new lunch schedule will help. But they know that they will have to prove that the new schedule really shortens the time that most students wait in line. They decide to measure the time students wait in line before the schedule change and then after the new schedule has started. The group knows that they can't time everyone in the lunch line; so they decide to time just a sample of the students.

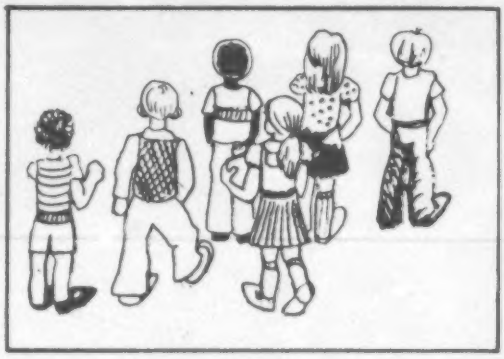


"How many students should be in our sample?" Jane asks Sue and Peter.

"First let's figure out how we're going to do it," suggests Peter. The group observes the lunch line and finds out that it takes a student about 1 minute to get his lunch when the line is moving very quickly but about 9 minutes when it's moving slowly.

"When the line is moving fast, each of us can time one student every minute."

"But when the line is moving slowly, we'll have to spend 9 minutes to time one student," complains Peter.



"Our sample has to be fair," says Jane. "We can't time more students when the line is going slowly."

"Let's choose every 5th student in line," Peter suggests. "Then it'll be the same no matter how fast or slow the line is moving."

"There are only three of us," says Sue. "When the line is going fast we may not be able to finish timing one student before we have to start timing another one."

"Let's see how big a sample we really need," Jane suggests. "Maybe we don't have to time every 5th student in line." The group looks at the tables in the "How To" booklet. They discover that they need to know the size of the group, or the number who eat lunch. They ask the lunchroom supervisor how many lunches are served every day and find out that about 420 students are served on an average day.

"Table I says that we need a sample of 40 or more for a group of 400 or more," says Peter.

BEFORE

"Wait a minute!" shouts Jane. "We want to prove that our new lunch schedule will shorten the time students have to wait in line. That means that we'll have to measure times before the schedule is changed and again after it has been changed. We'll have two samples that we'll want to compare."

"Then we should use Table II," says Sue. That table is for two groups that are to be compared.

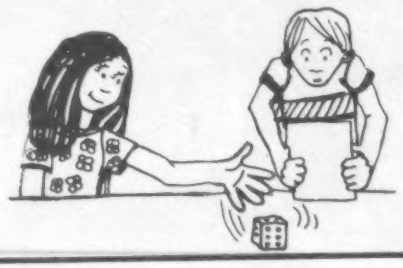
AFTER

"That makes the size of each sample 58, not 40," says Peter. The group agrees and goes back to the discussion of how they are going to do the timing.

"With a sample of 58 from a group of about 420 we can time every 7th student," says Sue as she divides 420 by 60 in her head. "That ought to be easy enough."

"Let's try to time every 6th student in line," suggests Jane. "We want to be sure to have enough." The group agrees and gets permission to do the timing the next day.

"How do we know where to start counting?" asks Peter. "Do we start with the first person in line?"



The group asks the teacher and he suggests that they throw a die to decide which person in line to time first. He explains that it will give each of the first six persons in line an equal chance of being chosen, and therefore everyone in line an equal chance of being timed at some point.

The next day the group follows their plan for taking the sample. They throw the die; the side numbered 2 lands up. Jane measures how long it takes the 2nd person in line to get his lunch. They then time every 6th student in line.

The group looks at their data. They see that they have timed 60 students. "That's a big enough sample," says Bob. "Our results should be all right."

"Let's time students on several more days," suggests Sue. "The line might be shorter than usual yesterday because so many students were absent." The group agrees with Sue.

On the next two days the group times every 6th person in the lunch line. Each day they throw the die to find out which person should be timed first.

When the group looks at their data, they discover that they have times for 192 students.

"That's a bigger sample than we need for the group of about 1200 students who were in the lunch line on the three days," says Peter. "If we'd known we were going to time students on three days, we could have taken a smaller sample each day."

"Let's take a smaller sample each day when we time students again after our new lunch schedule has started," suggests Jane. The group heartily agrees.

Two weeks after the new lunch schedule starts, Peter, Jane, and Sue start taking another sample survey. They time students on three days when the same lunch is being served. They do the timing the same way. This time, however, they pick every 14th student in line. "That will certainly give us the 80 students we need for a group of 1000 or more," says Peter who is reading Table II.

Each day, instead of throwing a die to decide which person to time first, the group writes the numbers 1 through 14 on rolled-up slips of paper. After placing the slips in a bowl and stirring them well, they pick a number.

After all the data are collected, the group looks at their data. Although they have fewer times recorded after the schedule change, they know that the number is enough for a good comparison.

The group reads "How To" Use Key Numbers to Compare Two Sets of Data. They decide to compare both the median and the middle range of the sample times recorded before the schedule change with the median and the middle range of sample times recorded after the schedule change.

CHOOSING A SAMPLE FOR YOUR SURVEY

You have read stories about students using different methods to choose samples for their surveys.

How should YOU choose a sample for YOUR survey? You can follow the same 6 steps the students in the stories followed. These steps can be used to choose samples from any total group. The group can be made up of people or things.

1. DECIDE WHAT GROUP OR GROUPS YOU ARE INTERESTED IN.

- Are you interested in all the students in the school, all the people in the community, or all the cars that pass the school?
- Are you interested in only primary children in the school, only people in the community who live near a dangerous crossing, or only cars that pass the school during certain hours?
- Are you interested in both primary and intermediate students as separate groups, people in different parts of the community as separate groups, or cars that pass the school at different times as separate groups?

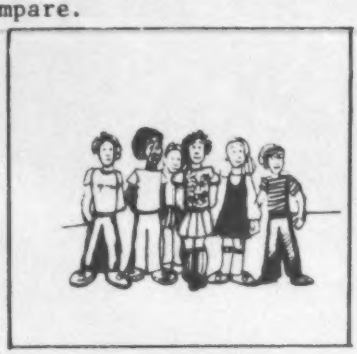
2. DECIDE WHETHER YOU WANT TO COMPARE TWO OR MORE GROUPS

- Do you want to compare something before and after a change is made?
- Do you want to compare boys and girls?
- Do you want to compare people who live in one part of the community with people who live in another part?
- Do you want to compare cars that pass the school in the morning with those that pass the school in the afternoon?

3. DECIDE HOW BIG YOUR SAMPLE SHOULD BE BY USING THE TABLES.

Look at the tables on page 15.

- Use Table I if you are choosing a sample from one group or from several groups that you don't want to compare.



- Use Table II if you are choosing samples from two or more groups that you want to compare.

BEFORE

AFTER

- Make your sample bigger to make up for students that might be absent the day you do the survey.

- Make your sample bigger if you want your results to be extremely accurate. (The tables give sample sizes that will give results that are accurate enough for most surveys.)

~~30~~ 38

~~40~~ 60

4. PICK A METHOD FOR CHOOSING YOUR SAMPLE.

The main thing to remember when you choose a sample is that each person should have an equal chance of being chosen. There are several good ways that will do this. Which method is best for you?

Can you use lists? If so, you can:

- Choose every 5th, or every 8th, or every 10th name from a list of names. Choose the number of the name to start with by asking someone to pick a number from 1 to 10, or by throwing a die.

- Give a number to each name on a list. Use a random number table to choose the names you will use for your sample.

GRADE 3

Agro, Jessica	Larkin, Beth
Andrews, Jason	Longwood, Fred
Hall, Joan	McInerny, Eric
Brady, Laura	Marshall, George
Cooper, Eloise	Peacock, Frances
Craft, Helen	Petraglia, Joseph
Dunn, Robert	Randolph, Michael
Finstein, Amy	Schneider, Greg
Grant, Alan	Stanton, Jane
Houlihan, Betsy	Stroud, Peter
Howe, Abigail	Thornton, Henry
Jackson, Randall	Walsh, Kerry
Lane, Sarah	Zifi, David

251630
595768
870011

10. ABLE, JOHN
11. ANTHONY, KAY
12. ARANO, JOSE
13. ATKINS, BARRY

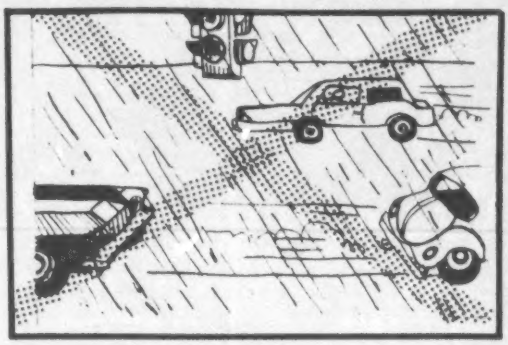
If you can't use lists, you can:

- Choose every 5th, every 7th, or every 12th person in a lunch line, in a line of cars, etc.

5. CHOOSE YOUR SAMPLE AND DO YOUR SURVEY.

- Are you choosing your sample the way you planned? You can't change the way you chose your sample after you've started. If you have made a change, you'll have to start again at the beginning.

- Are you conducting your sample survey so that nothing changes the result such as a rainy day, a different lunch being served, etc? If not, you'd better do it again. You can read "How To" Make a Survey. It may keep you from making mistakes.



6. THINK CAREFULLY ABOUT YOUR RESULTS.

- Do your results make sense? You can read "How To" Tell What Your Data Show.

- Did each person in the total group have an equal chance of being chosen for the sample? If not, you'd better do it again.

- Are you sure that your sample was a fair one but you are still not sure about your results? You may want to check them by conducting another survey--the same way, the same size sample chosen by the same method. If you get the same results the second time, you can be more sure that your results are right.

SURVEY RESULTS	OCT 10	
ITEM	VOTES	TOTAL
Notebooks	𝍸 𝍸 I	11
Pencils	𝍸 𝍸 𝍸 𝍸 II	27
Pens	𝍸 𝍸 𝍸 𝍸 𝍸	30
Paper	𝍸	5
Erasers	𝍸 𝍸 II	12

SURVEY RESULTS	OCT. 17	
ITEM	VOTES	TOTAL
Notebooks	𝍸 𝍸 𝍸 III	18
Pencils	𝍸 𝍸 𝍸 𝍸	26
Pens	𝍸 𝍸 𝍸 𝍸 III	23
Paper	III	3
Erasers	𝍸 𝍸 II	12

HOW BIG TO MAKE YOUR SAMPLE

TABLE I

Use this table if you are choosing your sample from one group or from several groups you don't want to compare.

Size of Group	Size of Sample
50	23
100	29
200	34
300	36
400 or more	40
Group of unknown size	40

TABLE II

Use this table if you are choosing samples from two or more groups that you want to compare.

Size of Group	Size of Sample
100	31
200	45
300	53
400	58
500	62
600	65
700	67
800	68
900	69
1000	71
More than 1000 or group of unknown size	80

(If you use the sample sizes in the tables the median of your sample will be within 10% of the median of the whole group four out of five times. This will be accurate enough for most surveys.)

RANDOM NUMBERS

To use a Random Number Table, you first drop a sharp pencil on the Table. You start with the digit nearest the first mark the pencil makes on the Table and use the digits going from left to right and line by line the same way you do when you read. You don't skip any digits. When you reach the bottom of the page, drop the pencil again and start at the new first digit.

If the size of your whole group is between 10 and 99, you take the digits two at a time. If the size of your whole group is between 100 and 999, you take the digits three at a time.

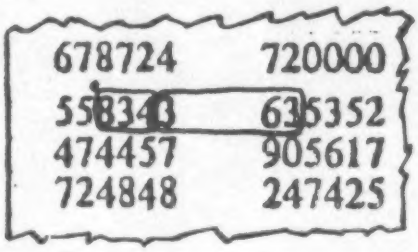


TABLE OF RANDOM NUMBERS

251630	188970	014150	214129	067312	718571
595768	971114	036525	107629	372393	329505
870011	199278	426340	184776	562236	815436
251863	737509	824449	900504	921737	011470
793997	643971	169205	327821	622024	781759
451972	533283	745225	670451	525624	950966
794648	460855	581519	118782	169303	336183
761608	734325	384145	608332	598301	291413
492036	807126	143870	634580	854092	794352
906318	383847	476141	196374	805132	192246
800887	707488	722567	366616	494316	691931
678724	720000	880890	130029	481331	900541
558343	635352	541310	546655	306931	281846
474457	905617	284811	834799	826841	639528
724848	247425	593485	453524	718619	136741
861119	241816	161871	153342	442767	512211
724746	277370	758319	159970	758616	120826
412282	092904	131413	239219	763611	996794
090767	042351	357417	200699	026374	278464
225011	862790	872401	882819	329593	886279
497211	598620	953678	700441	589973	441482
157868	875508	719152	000231	230280	783326
246869	163439	753634	498916	822360	240086
776378	416056	596173	488670	490907	093399
455479	445874	284050	414980	720288	340607
949504	146521	629028	654158	342434	697835
482593	629593	891704	305520	473721	031750
519302	947665	643829	978293	478940	154687
432444	482775	982096	163646	542584	341145
428207	410888	222885	707401	525704	910350
175514	750489	683860	362880	878739	516059
221223	049031	472877	173343	928304	149117
481210	280580	418671	771059	621065	540785
073950	795521	794405	600604	780334	325852
589055	721639	618498	569932	666067	427929
504352	680467	805648	709971	594813	700622
186542	449103	045547	708185	984996	169614
592164	787417	171983	094557	589317	325726
047670	076544	637625	366947	464958	069170
374038	699590	307943	047180	326825	055111
245991	314083	458897	535841	857710	810559
987871	122147	614713	711812	776743	584853

Taken from The Rand Corporation, *A Million Random Digits* (Free Press of Glencoe, 1955, with permission).

Example:

You are picking a sample from a group of 700 people. The digit closest to the first pencil mark is 0. You take the digits in groups of three.

The first three digits are 018. 18 is your first number. The next three digits are 897. 897 is a larger number than you can use. You go on to the next three digits which are 001. You use 1 as the second number for your sample. The next three digits are 415. You can use 415. It is the third number for your sample.

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